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CHEMICAL DESULFURIZATION OF COAL: REPORT OF BENCH-SCALE DEVELOPMENTS

VOLUME 2

TRW SYSTEMS GROUP

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16. Abstracts Bench-scale and laboratory tests were conducted for chemical removal of sulfur (S) from coal. Approximately 100% of pyritic S was removed, using aqueous ferric salt solutions which, for the four coals tested, corresponded to an absolute removal of 1-3.5% by coal weight of S. The heat content of the coal increased and the ash content decreased as a result of the pyrite removal. The pyritic S was removed from the coal as elemental S (40 mole %) and iron sulfate (60 mole %). Process operating temperatures of 50-130C, pressures of 1-10 atm, residence times of 1-16 hrs, and coal top sizes from 1/4-in. to 100 mesh were evaluated. Preliminary process design and cost estimation for a 100-ton/hr coal desulfurization plant indicated a cost of $2-3/ton of coal for removal of pyritic S from unwashed Appalachian or Eastern Interior Basin coals, depending on the amount of S removal required to produce a fuel which will comply with air quality regulations for fuel combustion and on any excess ferric ion consumption. Results of organic S removal tests indicate that additional studies are necessary before process feasibility can be assessed.

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APPENDIX "A'

L.:BORATORY EXPERIMENTATION

APPENDIX A-1. COMPUTER PROGRAM FOR ANALYSIS OF FERRIC CHLORIDE AND FERRIC SULFATE EXTRACTIONS OF PYRITIC SULFUR FROM COAL

```
      PROGRAM WARR (OUTPUT,TAPE8)
C     DIMENSION STATEMENTS FOR PROGRAM VARIABLES
     1 DIMENSION SF(50),ASHF(50),BTUF(50),FE2F(50),FE3IN(50)
     2 DIMENSION CF(50),CI(50),AMS(50), AMSO4(50)
     3 DIMENSION SLOSS(50),ASHLOSS(50),BTUGAIN(50),SAHLOSS(50),ASHR(50),
      1ASHREL(50),BTUFAC(50),FES2REM(50),CFT(50),TOTREC(50),XMATCLS(50),
      2AMSF(50),AMSI(50),AMPLOSS(50),AMFS(50),SULSUM(50),SBAL(50)
      DIMENSION SO4RAT(50),BTU(50),BTUREL(50),BTUCOR(50),AMFE2(50),FE3US
      1ED(50),SREM(50),FERATIO(50)
C     INPUT VARIABLES-NON SUBSCRIPTED.  ONLY ONE COAL PER RUN.
C     SI=INITIAL SULFUR,ASHI=INITIAL ASH,BTUI=INITIAL BTU,SP=INITIAL PYR
C     ITIC SULFUR
   10 REWIND 8
      ACCEPT (8) I
   11 ACCEPT(8) SI,SP,ASHI,BTUI
C     INPUT VARIABLES-SUBSCRIPTED
C     I=SUBSCRIPT-NUMBER OF RUNS,SF=FINAL SULFUR,ASHF=FINAL ASH,BTUF=FIN
C     AL BTU,CI=INITIAL COAL WT.,CF=FINAL COAL WT.,FE2F=FINAL FE(2),
C     FE3IN=INITIAL FE(3). COAL IS DRY WEIGHT. IRON IS IN MM.
   12 ACCEPT  (8) (SF(J),J=1,I),(ASHF(J),J=1,I),(BTUF(J),J=1,I),
     1           (CI(J),J=1,I),(CF(J),J=1,I),(FE3IN(J),J=1,I),(FE2F(J),
     2J=1,I),(AMS(J),J=1,I),(AMSO4(J),J=1,I)
C     COMPUTATION OF SULFUR,ASH AND BTU CHANGE AND ASH BALANCE
   20 DO 100 J=1,I
   21 SLOSS(J)=SI-SF(J)
   22 ASHLOSS(J)=ASHI-ASHF(J)
   23 BTUGAIN(J)=-(BTUI-BTUF(J))
C     SAHLOSS=ASH LOSS CALCULATED FROM SULFUR LOSS
   24 SAHLOSS(J)=SLOSS(J)*1.26
   25 ASHR(J)=ASHLOSS(J)/SAHLOSS(J)
C     ASHR=(ACTUAL ASH LOSS)/(ASH LOSS CALCULATED FROM SULFUR LOSS.
   26 ASHREL(J)=(ASHLOSS(J)/ASHI)*100.
C     ASHREL= PERCENT OF TOTAL ASH THAT IS REMOVED
C     BTUFAC=IF ASH LOSS IS LESS THAN CALCULATED, THE FINAL BTU VALUE IS
C     CORRECTED BY THIS VALUE
   27 BTUFAC(J)=(100.-(SAHLOSS(J)-ASHLOSS(J)))/100.
   28 IF(1.0-BTUFAC(J))  29,30,30
   29 BTUFAC(J)=1.0
C     CALCULATION OF MATERIAL BALANCE
C     FES2REM=WT. PYRITE REMOVED
C     CFT=FINAL COAL WEIGHT IF ONLY PYRITE IS REMOVED
   30 FES2REM(J)=SLOSS(J)*CI(J)*0.01871
   31 CFT(J)=CI(J)-FES2REM(J)
C     TOTREC=TOTAL ACCOUNTABLE WEIGHT
C     MATCLOS=PERCENT MASS ACCOUNTED FOR
   32 TOTREC(J)=CF(J)+FES2REM(J)
   33 XMATCLS(J)=(TOTREC(J)/CI(J))*100.
C     CALCULATION OF SULFUR BALANCE
C     AMSF=MMOLES SULFUR AFTER TREATMENT IN THEORY
C     AMSI=MMOLES SULFUR IN STARTING COAL
C     AMPLOSS=MMOLOES PYRITIC SUFUR LOST BASED ON SULFUR LOSS ANALYSIS
C     AMFS=MMOLES SULFUR IN FINAL COAL
```

```
   40 AMSF(J)=(CFT(J)*SF(J))/3.2
   41 AMSI(J)=(CI(J)*SI)/3.2
   42 AMPL@SS(J)=AMSI(J)-AMSF(J)
   43 AMFS(J)=(CF(J)*SF(J))/3.2
   44 SULSUM(J)=AMFS(J)+AMS(J)+AMS@4(J)
   45 SBAL(J)=(SULSUM(J)/AMSI(J))*100.
   47 IF(AMS(J).EQ.0) SBAL(J)=0.0
   48 IF(AMS(J))      49,49,50
   49 AMS(J)=(AMPL@SS(J)-AMS@4(J))*(XMATCLS(J)/100.)
      SULSUM(J)=0.0
   50 S@4RAT(J)=AMS@4(J)/AMS(J)
   54 SREM(J)=(SL@SS(J)/SP)*100.
C     C@MPUTATI@N @F BTU BALANCE
C     BTU=BTU CHANGE,BTUREL=PERCENT CHANGE,BTUC@R=PERCENT CHANGE C@RRECT
C     ED F@R ASH AND PYRITE REM@VAL
C     SEE 23
   51 BTUREL(J)=(BTUGAIN(J)/BTUI)*100.
      BTUC=BTUI-((FES2REM(J)/CI(J))*2995.)
   52 BTUC@R(J)=-(((BTUI-(BTUF(J)/BTUFAC(J)))/BTUC)*100.)
C     C@MPUTATI@N @F IR@N BABANCE
   60 AMFE2(J)=(AMS@4(J)*7.5)+(AMS(J)*1.5)
   61 FE3USED(J)= ((FE2F(J)-(AMPL@SS(J)/2.))/FE3IN(J))*100.
   62 FERATI@(J)=FE2F(J)/AMFE2(J)
       PRINT 202, ASHL@SS(J),BTUREL(J),SBAL(J),XMATCLS(J),
     1FERATI@(J),S@4RAT(J),SREM(J)
  100 C@NTINUE
      PRINT 700
  700 F@RMAT (//////////)
      PRINT 200
  200 F@RMAT  (28X*DATA SUAMARY*//10X*BTU*7X*SULFUR    MATERIAL  FE2(EXP
     1T) SULFATE   SULFUR*/*ASH L@SS  CHANGE    CL@SURE   CL@SURE*
     23X*FE2(CALC) SULFUR    REM@VED*/4X*%*8X*%*9X*%*9X*%*28X*%*)
  201 D@ 205 J=1,I
      PRINT 202, ASHL@SS(J),BTUREL(J),SBAL(J),XMATCLS(J),FERATI@(J),S@4R
     1AT(J),SREM(J)
  202 F@RMAT (F6.1,6F10.2)
  205 C@NTINUE
C     DATA SUMMARY @UTPUT
      PRINT 700
      PRINT 300
  300 F@RMAT (16X*IR@N BALANCE*//*FE3*6X*FE2*4X*FE3*4X*FE2*4X*FE2(EXPT)*
     1/*INITIAL  FINAL  USED   CALC   FE2(CALC)*/2X*MM*6X*MM*6X*%*
     2*     MM*)
  301 D@ 305 J=1,I
      PRINT 302, FE3IN(J),FE2F(J),FE3USED(J),AMFE2(J),FERATI@(J)
  302 F@RMAT (F5.0,F8.0,F7.1,F6.0,F8.2)
  305 C@NTINUE
      PRINT 700
C     IR@N BALANCE @UTPUT
C     MATERIAL BALANCE-C@AL @UTPUT
      PRINT 400
```

```
  400 FORMAT (11X*COAL MATERIAL BALANCE*//*INITIAL  FINAL    PYRITE   TO
     1TAL    RECOVERY*/*WEIGHT   WEIGHT   REMOVED  WEIGHT*/3X*G*
     28X*G*8X*G*8X*G*8X*%*)
  401 DO 405 J=1,I
  402 PRINT 403, CI(J),CF(J),FES2REM(J),TOTREC(J),XMATCLS(J)
  403 FORMAT (F5.1,4F9.1)
  405 CONTINUE
      PRINT 700
C     SULFUR BALANCE OUTPUT
      PRINT 500
  500 FORMAT (25X*SULFUR BALANCE*//X*FINAL  PYRITIC  TOLUENE  SULFATE  T
     1OTAL       SULFUR   SULFATE*/X*COAL*3X*LOSS      EXTRACT*11X*RECOVER
     2ED  BALANCE  SULFUR*/2X*%S*5X*MM S*5X*MM S*4X          *MM SO4*5X*MM
     3 S*8X*%*)
  501 DO 505 J=1,I
  502 PRINT 503, SF(J),AMPLOSS(J),AMS(J),AMSO4(J),SULSUM(J),SBAL(J),SO4
     1RAT(J)
  503 FORMAT (F5.2,F8.1,2F9.1,2F10.1,F9.2)
  505 CONTINUE
C     OUTPUT - BTU AND ASH DATA
      PRINT 700
      PRINT 600
  600 FORMAT (11X*ASH DATA*19X*BTU DATA*//*ASH*4X*ASH*4X*ASH*4X*ASH(EXPT
     1)  BTU*5X*BTU*5X*FINAL  COR BTU*/*LOSS*3X*LOSS*3X*FINAL  ASH(CALC)
     2 *1X*CHANGE  CHANGE  BTU*        /*ABS %  REL %*4X*%*23X*REL %*10
     3X*REL %*)
  601 DO 605 J=1,I
  602 PRINT 603, ASHLOSS(J),ASHREL(J),ASHF(J),ASHR(J),BTUGAIN(J),BTUREL(
     1J),BTUF(J),BTUCOR(J)
  603 FORMAT (F4.2,F6.1,F9.2,F9.2,4X,F6.0,F7.2,F8.0,F8.1)
  605 CONTINUE
      PRINT 700
      END
```

APPENDIX A-2. FERRIC CHLORIDE EXPERIMENTATION

General Reaction Conditions:

a) 540 mM 0.9M $FeCl_3$ in 0.3M HCl per 100 g -100 mesh coal

b) 2.0 hour reaction time

c) Coal filtered, washed, then extracted 1 hour with 300 ml toluene

d) Dried overnight at 150-170°C and cooled under vacuum

Specific Reaction Conditions:

Index (J)	Variable Change
1,2	-14 mesh coal
3,4	2 hours leach time
5,6	6 hours leach time
7	12 hours leach time
8,9	0.0M HCl
10,11	0.1M HCl
12,13 (same expts as 3,4)	0.3M HCl
14,15	1.2M HCl
16	Dummy value average for Runs 8-15
17,18	Reaction value diluted to twice the volume

NOTE: Index number (J) is the same for each coal.

LØWER KITTANNING CØAL

INITIAL ASH=20.77%, INITIAL BTU=12140, INITIAL ASH FREE BTU=15069

INITIAL SULFUR=4.29%, INITIAL PYRITIC SULFUR=3.58%

DATA SUMMARY

ASH(EXPT) ASH(CALC)	BTU-ASH FREE	SULFUR CLØSURE	MATERIAL CLØSURE	FE2(EXPT) FE2(CALC)	SULFATE SULFUR	SULFUR REMØVED		Run
	%	%	%			%	J	
1.26	100.0	97.4	99.8	1.05	1.09	55.0	1	49
1.79	102.0	0.0	100.0	1.03	1.12	50.8	2	20
.99	98.7	86.8	97.2	1.27	1.44	49.2	3	21
.95	98.8	84.2	96.7	1.28	1.41	47.5	4	22
.85	98.2	95.7	100.4	1.34	2.03	60.1	5	23
.75	99.5	0.0	94.4	1.61	.49	51.7	6	24
.60	100.5	100.7	95.3	1.25	1.48	63.4	7	25
.39	100.0	111.1	99.9	1.19	1.57	41.6	8	26
.20	98.6	0.0	100.9	1.19	2.08	44.1	9	27
1.08	101.2	107.2	99.6	1.18	1.36	46.9	10	28
-.43	99.4	0.0	99.5	1.81	1.91	36.3	11	29
.99	98.7	86.8	97.2	1.27	1.44	49.2	12	21
.95	98.8	84.2	96.7	1.28	1.41	47.5	13	22
.15	99.2	110.5	98.1	1.35	1.08	36.0	14	30
.66	98.2	0.0	100.3	1.43	2.05	38.3	15	31
1.06	100.1	97.2	99.7	1.22	1.44	42.5	16	
.91	100.0	104.5	101.2	1.06	1.28	59.5	17	
1.39	100.8	107.6	99.1	1.09	1.75	59.2	18	

SULFUR BALANCE

FINAL CØAL %S	PYRITIC LØSS MM S	TØLUENE EXTRACT MM S	SULFATE MM SØ4	TØTAL RECØVERED MM S	SULFUR BALANCE %	SULFATE SULFUR		Run
							J	
2.32	59.7	27.1	29.5	121.4	97.4	1.09	1	49
2.47	56.9	26.5	29.8	0.0	0.0	1.12	2	20
2.53	56.5	16.9	24.4	114.1	86.8	1.44	3	21
2.59	54.5	15.1	21.3	110.5	84.2	1.41	4	22
2.14	61.9	18.7	37.9	113.7	95.7	2.03	5	23
2.44	52.9	33.7	16.5	0.0	0.0	.49	6	24
2.02	65.0	27.6	40.8	119.2	100.7	1.48	7	25
2.80	43.5	22.1	34.7	132.1	111.1	1.57	8	26
2.71	47.3	15.3	31.8	0.0	0.0	2.08	9	27
2.61	48.8	24.4	33.3	127.5	107.2	1.36	10	28
2.99	38.7	13.2	25.2	0.0	0.0	1.91	11	29
2.53	56.5	16.9	24.4	114.1	86.8	1.44	12	21
2.59	54.5	15.1	21.3	110.5	84.2	1.41	13	22
3.00	38.1	25.1	27.2	132.5	110.5	1.08	14	30
2.92	39.8	13.0	26.6	0.0	0.0	2.05	15	31
2.77	44.4	16.9	24.4	115.8	97.2	1.44	16	
2.16	64.1	30.2	38.8	129.7	104.5	1.28	17	
2.17	63.6	26.7	46.3	133.0	107.6	1.75	18	

INITIAL SULFUR=4.29%, INITIAL PYRITIC SULFUR=3.58%

ASH DATA

BTU DATA

ASH LØSS ABS %	ASH LØSS REL %	ASH FINAL %	ASH(EXPT) ASH(CALC)	FINAL BTU	BTU CHANGE REL %	BTU-ASH FREE	BTU-ASH FREE REL %	J	Run
3.13	15.1	17.64	1.26	12436	2.43	15065	100.0	1	49
4.10	19.7	16.67	1.79	12842	5.75	15369	102.0	2	20
2.20	10.6	18.57	.99	12150	.08	14870	98.7	3	21
2.03	9.8	18.74	.95	12145	.04	14890	98.8	4	22
2.30	11.1	18.47	.85	12087	-.43	14801	98.2	5	23
1.74	8.4	19.03	.75	12176	.30	14993	99.5	6	24
1.72	8.3	19.05	.60	12277	1.12	15151	100.5	7	25
.74	3.6	20.03	.39	12109	-.25	15070	100.0	8	26
.39	1.9	20.38	.20	11882	-2.11	14857	98.6	9	27
2.29	11.0	18.48	1.08	12471	2.71	15243	101.2	10	28
-.70	-3.4	21.47	-.43	11830	-2.54	14976	99.4	11	29
2.20	10.6	18.57	.99	12150	.08	14870	98.7	12	21
2.03	9.8	18.74	.95	12145	.04	14890	98.8	13	22
.24	1.2	20.53	.15	11953	-1.53	14954	99.2	14	30
1.14	5.5	19.63	.66	11957	-1.50	14797	98.2	15	31
2.03	9.8	18.74	1.06	12310	1.39	15082	100.1	16	
2.45	11.8	18.32	.91	12333	1.58	15075	100.0	17	
3.70	17.8	17.07	1.39	12614	3.89	15187	100.8	18	

INITIAL ASH=20.77%, INITIAL BTU=12140, INITIAL ASH FREE BTU=15069

IRØN BALANCE

FE3 INITIAL MM	FE2 FINAL MM	FE3 USED %	FE2 CALC MM	FE2(EXPT) FE2(CALC)	J	Run
524	274	46.6	262	1.05	1	49
524	270	46.1	263	1.03	2	20
471	264	50.1	208	1.27	3	21
471	233	43.7	182	1.28	4	22
472	419	82.2	312	1.34	5	23
472	280	53.7	174	1.61	6	24
472	435	85.3	347	1.25	7	25
446	348	73.2	293	1.19	8	26
446	310	64.2	261	1.19	9	27
443	339	71.0	286	1.18	10	28
452	378	79.3	209	1.81	11	29
471	264	50.1	208	1.27	12	21
471	233	43.7	182	1.28	13	22
493	326	62.3	242	1.35	14	30
484	313	60.6	219	1.43	15	31
447	255	52.1	208	1.22	16	
526	356	61.6	336	1.06	17	
526	425	74.8	391	1.09	18	

CØAL MATERIAL BALANCE

INITIAL WEIGHT G	FINAL WEIGHT G	PYRITE REMØVED G	TØTAL WEIGHT G	RECØVERY %	J	Run
93.0	89.4	3.4	92.8	99.8	1	49
95.6	92.3	3.3	95.6	100.0	2	20
98.1	92.1	3.2	95.3	97.2	3	21
97.8	91.5	3.1	94.6	96.7	4	22
88.6	85.4	3.6	89.0	100.4	5	23
87.5	79.6	3.0	82.6	94.4	6	24
88.3	80.4	3.8	84.2	95.3	7	25
88.7	86.1	2.5	88.6	99.9	8	26
91.1	89.2	2.7	91.9	100.9	9	27
88.7	85.6	2.8	88.4	99.6	10	28
90.2	87.6	2.2	89.8	99.5	11	29
98.1	92.1	3.2	95.3	97.2	12	21
97.8	91.5	3.1	94.6	96.7	13	22
89.4	85.5	2.2	87.7	98.1	14	30
88.2	86.2	2.3	88.5	100.3	15	31
88.9	86.1	2.5	88.6	99.7	16	
92.6	90.0	3.7	93.7	101.2	17	
92.2	87.7	3.7	91.4	99.1	18	

ILLINOIS #5 COAL

INITIAL ASH=10.96%, INITIAL BTU=12801, INITIAL ASH FREE BTU=14278

INITIAL SULFUR=3.48%, INITIAL PYRITIC SULFUR=1.57%

DATA SUMMARY

ASH(EXPT) ASH(CALC)	BTU-ASH FREE %	SULFUR CLOSURE %	MATERIAL CLOSURE %	FE2(EXPT) FE2(CALC)	SULFATE SULFUR	SULFUR REMOVED %	J	Run
2.92	98.6	0.0	102.6	3.71	.76	36.3	1	34
6.68	97.1	0.0	100.9	4.03	8.10	19.7	2	35
1.74	96.7	82.2	87.2	6.91	1.20	40.1	3	36
2.07	98.0	81.3	87.5	7.35	1.81	40.1	4	37
1.13	96.6	87.9	99.1	5.37	1.51	66.9	5	38
1.93	97.5	0.0	96.8	6.20	.45	58.6	6	39
2.25	98.0	95.3	99.5	5.11	1.48	52.9	7	40
1.89	98.2	97.1	96.2	4.03	1.47	50.3	8	41
2.14	97.6	97.3	96.3	4.24	2.70	42.0	9	42
1.47	98.3	0.0	98.1	3.66	.98	47.1	10	43
1.59	98.0	0.0	98.4	3.84	2.07	48.4	11	44
1.74	96.7	82.2	87.2	6.91	1.20	40.1	12	36
2.07	98.0	81.3	87.5	7.35	1.81	40.1	13	37
-.99	94.4	38.7	98.0	6.83	1.30	50.3	14	45
.94	97.1	0.0	99.7	6.34	.28	62.4	15	46
1.61	97.9	98.2	96.2	4.03	1.47	47.8	16	
2.40	97.4	99.0	97.8	3.65	1.77	49.0	17	
1.89	96.5	100.5	98.6	3.09	1.97	66.2	18	

SULFUR BALANCE

FINAL COAL %S	PYRITIC LOSS MM S	TOLUENE EXTRACT MM S	SULFATE MM SO4	TOTAL RECOVERED MM S	SULFUR BALANCE %	SULFATE SULFUR	J	Run
2.91	17.6	9.8	7.4	0.0	0.0	.76	1	34
3.17	9.3	1.0	8.2	0.0	0.0	8.10	2	35
2.85	18.2	5.1	6.1	78.6	82.2	1.20	3	36
2.85	18.2	3.6	6.5	77.8	81.3	1.81	4	37
2.43	27.1	6.9	10.4	75.5	87.9	1.51	5	38
2.56	24.0	15.4	6.9	0.0	0.0	.45	6	39
2.65	22.4	7.5	11.1	85.4	95.3	1.48	7	40
2.69	20.5	8.3	12.2	83.4	97.1	1.47	8	41
2.82	17.2	4.7	12.7	83.7	97.3	2.70	9	42
2.74	19.3	9.3	9.1	0.0	0.0	.98	10	43
2.72	20.0	6.3	13.1	0.0	0.0	2.07	11	44
2.85	18.2	5.1	6.1	78.6	82.2	1.20	12	36
2.85	18.2	3.6	6.5	77.8	81.3	1.81	13	37
2.69	20.7	5.3	6.9	76.8	88.7	1.30	14	45
2.50	25.2	18.6	5.2	0.0	0.0	.28	15	46
2.73	19.5	8.3	12.2	84.4	98.2	1.47	16	
2.71	21.0	7.8	13.8	89.3	99.0	1.77	17	
2.44	29.5	10.4	20.5	94.9	100.5	1.97	18	

INITIAL SULFUR=3.48%, INITIAL PYRITIC SULFUR=1.57%

ASH DATA

BTU DATA

ASH LØSS ABS %	ASH LØSS REL %	ASH FINAL %	ASH(EXPT) ASH(CALC)	FINAL BTU	BTU CHANGE REL %	BTU-ASH FREE	BTU-ASH FREE REL %	J	Run
2.10	19.2	8.86	2.92	12618	-1.40	14073	98.6	1	34
2.61	23.8	8.35	6.68	12520	-2.15	13869	97.1	2	35
1.38	12.6	9.58	1.74	12284	-3.96	13811	96.7	3	36
1.64	15.0	9.32	2.07	12486	-2.41	13999	98.0	4	37
1.49	13.6	9.47	1.13	12260	-4.14	13794	96.6	5	38
2.24	20.4	8.72	1.93	12481	-2.45	13920	97.5	6	39
2.35	21.4	8.61	2.25	12569	-1.78	13996	98.0	7	40
1.88	17.2	9.08	1.89	12533	-2.05	14025	98.2	8	41
1.78	16.2	9.18	2.14	12448	-2.70	13937	97.6	9	42
1.37	12.5	9.59	1.47	12473	-2.51	14033	98.3	10	43
1.52	13.9	9.44	1.59	12451	-2.68	13986	98.0	11	44
1.38	12.6	9.58	1.74	12284	-3.96	13811	96.7	12	36
1.64	15.0	9.32	2.07	12486	-2.41	13999	98.0	13	37
-.99	-9.0	11.95	-.99	11665	-8.69	13476	94.4	14	45
1.16	10.6	9.80	.94	12284	-3.96	13867	97.1	15	46
1.52	13.9	9.44	1.61	12448	-2.70	13982	97.9	16	
2.33	21.3	8.63	2.40	12495	-2.34	13912	97.4	17	
2.48	22.6	8.48	1.89	12381	-3.21	13779	96.5	18	

INITIAL ASH=10.96%, INITIAL BTU=12801, INITIAL ASH FREE BTU=14278

IRØN BALANCE

FE3 INITIAL MM	FE2 FINAL MM	FE3 USED %	FE2 CALC MM	FE2(EXPT) FE2(CALC)	J	Run
524	260	47.9	70	3.71	1	34
498	254	50.1	63	4.03	2	35
462	369	77.9	53	6.91	3	36
462	398	84.2	54	7.35	4	37
463	474	99.4	88	5.37	5	38
472	464	95.8	75	6.20	6	39
481	483	98.1	94	5.11	7	40
437	419	93.5	104	4.03	8	41
446	434	95.4	102	4.24	9	42
435	301	67.0	82	3.66	10	43
443	414	91.2	108	3.84	11	44
462	369	77.9	53	6.91	12	36
462	398	84.2	54	7.35	13	37
484	408	82.2	60	6.83	14	45
484	424	85.0	67	6.34	15	46
437	419	93.7	104	4.03	16	
516	420	79.4	115	3.65	17	
573	524	88.9	169	3.09	18	

COAL MATERIAL BALANCE

INITIAL WEIGHT G	FINAL WEIGHT G	PYRITE REMOVED G	TOTAL WEIGHT G	RECOVERY %	J	Run
93.8	95.2	1.0	96.2	102.6	1	34
90.4	90.7	.5	91.2	100.9	2	35
88.0	75.7	1.0	76.7	87.2	3	36
88.0	76.0	1.0	77.0	87.5	4	37
79.0	76.7	1.6	78.3	99.1	5	38
79.6	75.7	1.4	77.1	96.8	6	39
82.4	80.7	1.3	82.0	99.5	7	40
79.0	74.8	1.2	76.0	96.2	8	41
79.1	75.2	1.0	76.2	96.3	9	42
79.4	76.8	1.1	77.9	98.1	10	43
80.1	77.7	1.1	78.8	98.4	11	44
88.0	75.7	1.0	76.7	87.2	12	36
88.0	76.0	1.0	77.0	87.5	13	37
79.7	76.9	1.2	78.1	98.0	14	45
78.7	77.0	1.4	78.4	99.7	15	46
79.0	74.9	1.1	76.0	96.2	16	
82.9	79.9	1.2	81.1	97.8	17	
86.8	83.9	1.7	85.6	98.6	18	

PITTSBURGH CØAL

INITIAL ASH=22.73%, INITIAL BTU=11493, INITIAL ASH FREE BTU=14787

INITIAL SULFUR=1.88%, INITIAL PYRITIC SULFUR=1.20%

DATA SUMMARY

ASH(EXPT) ASH(CALC)	BTU-ASH FREE %	SULFUR CLØSURE %	MATERIAL CLØSURE %	FE2(EXPT) FE2(CALC)	SULFATE SULFUR	SULFUR REMØVED %	J	Run
1.53	99.3	0.0	98.8	1.31	.95	49.2	1	49
3.98	100.3	87.8	81.8	1.37	1.34	40.8	2	50
1.85	105.1	0.0	101.7	2.48	1.38	57.5	3	51
1.14	96.8	0.0	100.5	2.56	1.01	60.8	4	52
1.23	94.5	101.6	100.2	2.67	.95	76.7	5	53
1.56	96.0	0.0	103.6	3.66	.66	75.0	6	54
2.12	97.8	112.5	100.9	2.90	.94	81.7	7	55
1.93	98.7	101.3	97.1	2.15	1.85	59.2	8	56
1.72	99.4	0.0	98.5	2.26	3.05	63.3	9	57
.56	103.4	98.1	96.3	3.32	1.31	62.5	10	58
.86	95.2	0.0	106.0	2.30	2.53	56.7	11	59
1.85	105.1	0.0	101.7	2.48	1.38	57.5	12	51
1.14	96.8	0.0	100.5	2.56	1.01	60.8	13	52
2.64	97.8	105.7	101.5	3.33	.85	56.7	14	60
2.24	97.9	0.0	102.4	3.46	1.01	50.0	15	61
1.55	99.7	104.3	100.5	2.46	1.31	58.3	16	
2.52	97.3	107.3	100.8	2.59	1.51	66.7	17	
2.53	98.8	115.3	100.2	1.65	1.58	56.7	18	

SULFUR BALANCE

FINAL CØAL %S	PYRITIC LØSS MM S	TØLUENE EXTRACT MM S	SULFATE MM S04	TØTAL RECØVERED MM S	SULFUR BALANCE %	SULFATE SULFUR	J	Run
1.29	19.5	9.9	9.4	0.0	0.0	.95	1	49
1.39	15.9	7.1	9.5	52.1	87.8	1.34	2	50
1.19	21.6	9.1	12.6	0.0	0.0	1.38	3	51
1.15	22.7	11.3	11.4	0.0	0.0	1.01	4	52
.96	29.0	15.3	14.6	59.2	101.6	.95	5	53
.98	28.5	17.5	11.6	0.0	0.0	.66	6	54
.90	31.1	19.7	18.5	66.0	112.5	.94	7	55
1.17	22.9	8.7	16.1	60.2	101.3	1.85	8	56
1.12	24.2	6.0	18.2	0.0	0.0	3.05	9	57
1.13	23.8	10.4	13.6	57.3	98.1	1.31	10	58
1.20	22.0	6.3	16.0	0.0	0.0	2.53	11	59
1.19	21.6	9.1	12.6	0.0	0.0	1.38	12	51
1.15	22.7	11.3	11.4	0.0	0.0	1.01	13	52
1.20	21.3	13.0	11.0	60.8	105.7	.85	14	60
1.28	18.9	9.5	9.6	0.0	0.0	1.01	15	61
1.18	21.7	10.4	13.6	59.5	104.3	1.31	16	
1.08	25.4	11.7	17.7	62.8	107.3	1.51	17	
1.20	22.9	12.5	19.7	71.2	115.3	1.58	18	

INITIAL SULFUR=1.88%, INITIAL PYRITIC SULFUR=1.20%

ASH DATA

BTU DATA

ASH LØSS ABS %	ASH LØSS REL %	ASH FINAL %	ASH(EXPT) ASH(CALC)	FINAL BTU	BTU CHANGE REL %	BTU-ASH FREE	BTU-ASH FREE REL %	J	Run
1.14	5.0	21.59	1.53	11490	-.03	14691	99.3	1	49
2.46	10.8	20.27	3.98	11798	2.64	14829	100.3	2	50
1.61	7.1	21.12	1.85	12226	6.34	15548	105.1	3	51
1.05	4.6	21.68	1.14	11179	-2.72	14318	96.8	4	52
1.43	6.3	21.30	1.23	10951	-4.69	13971	94.5	5	53
1.77	7.8	20.96	1.56	11181	-2.70	14202	96.0	6	54
2.62	11.5	20.11	2.12	11500	.06	14458	97.8	7	55
1.73	7.6	21.00	1.93	11497	.03	14598	98.7	8	56
1.65	7.3	21.08	1.72	11561	.59	14698	99.4	9	57
.53	2.3	22.20	.56	11851	3.10	15284	103.4	10	58
.74	3.3	21.99	.86	10956	-4.65	14084	95.2	11	59
1.61	7.1	21.12	1.85	12226	6.34	15548	105.1	12	51
1.05	4.6	21.68	1.14	11179	-2.72	14318	96.8	13	52
2.26	9.9	20.47	2.64	11462	-.27	14455	97.8	14	60
1.69	7.4	21.04	2.24	11401	-.80	14476	97.9	15	61
1.37	6.0	21.36	1.55	11561	.59	14746	99.7	16	
2.54	11.2	20.19	2.52	11443	-.43	14388	97.3	17	
2.17	9.5	20.56	2.53	11576	.72	14615	98.8	18	

INITIAL ASH=22.73%, INITIAL BTU=11493, INITIAL ASH FREE BTU=14787

IRØN BALANCE

FE3 INITIAL MM	FE2 FINAL MM	FE3 USED %	FE2 CALC MM	FE2(EXPT) FE2(CALC)	J	Run
524	112	19.5	85	1.31	1	49
524	112	19.9	82	1.37	2	50
524	268	49.1	108	2.48	3	51
524	262	47.8	102	2.56	4	52
524	353	64.6	132	2.67	5	53
533	415	75.2	113	3.66	6	54
533	488	88.6	168	2.90	7	55
495	288	55.9	134	2.15	8	56
495	329	64.0	145	2.26	9	57
493	390	76.7	118	3.32	10	58
501	298	57.3	129	2.30	11	59
524	268	49.1	108	2.48	12	51
524	262	47.8	102	2.56	13	52
538	340	61.2	102	3.33	14	60
547	298	52.8	86	3.46	15	61
524	289	53.1	118	2.46	16	
573	390	65.8	150	2.59	17	
621	274	42.3	166	1.65	18	

CØAL MATERIAL BALANCE

INITIAL WEIGHT G	FINAL WEIGHT G	PYRITE REMØVED G	TØTAL WEIGHT G	RECØVERY %	J	Run
103.1	100.7	1.1	101.8	98.8	1	49
101.1	81.8	.9	82.7	81.8	2	50
97.9	98.3	1.3	99.6	101.7	3	51
97.2	96.4	1.3	97.7	100.5	4	52
99.2	97.7	1.7	99.4	100.2	5	53
99.6	101.5	1.7	103.2	103.6	6	54
99.9	99.0	1.8	100.8	100.9	7	55
101.1	96.8	1.3	98.1	97.1	8	56
100.0	97.1	1.4	98.5	98.5	9	57
99.5	94.4	1.4	95.8	96.3	10	58
101.1	105.9	1.3	107.2	106.0	11	59
97.9	98.3	1.3	99.6	101.7	12	51
97.2	96.4	1.3	97.7	100.5	13	52
97.9	98.1	1.2	99.3	101.5	14	60
98.2	99.5	1.1	100.6	102.4	15	61
97.2	96.4	1.3	97.7	100.5	16	
99.6	98.9	1.5	100.4	100.8	17	
105.2	104.1	1.3	105.4	100.2	18	

HERRIN #6 CØAL

INITIAL ASH=10.31%, INITIAL BTU=12684, INITIAL ASH FREE BTU=14039

INITIAL SULFUR=3.80%, INITIAL PYRITIC SULFUR=1.65%

DATA SUMMARY

ASH(EXPT) ASH(CALC)	BTU-ASH FREE %	SULFUR CLØSURE %	MATERIAL CLØSURE %	FE2(EXPT) FE2(CALC)	SULFATE SULFUR	SULFUR REMØVED %	J	Run
.89	100.0	76.5	90.3	5.36	1.22	67.9	1	64
.45	99.5	0.0	101.4	3.74	.35	72.1	2	65
2.54	96.9	94.3	95.5	5.42	1.14	41.8	3	66
2.59	98.0	90.7	97.8	9.66	.56	39.4	4	67
1.49	98.2	93.8	100.3	4.22	1.15	70.3	5	68
1.73	97.3	88.2	98.1	5.76	1.28	61.8	6	69
1.83	97.4	99.3	97.8	4.21	1.13	64.2	7	70
1.65	98.2	100.1	98.9	3.28	1.99	51.5	8	71
1.23	98.4	0.0	98.7	3.48	1.96	64.8	9	72
2.04	98.0	0.0	97.7	2.53	2.98	53.9	10	73
1.65	98.0	95.9	97.1	3.67	1.39	49.1	11	66
2.54	96.9	94.3	95.5	5.42	1.14	41.8	12	67
2.59	98.0	90.7	97.8	9.66	.56	39.4	13	76
1.16	96.9	92.2	99.5	6.68	1.22	46.7	14	75
-.25	98.6	0.0	101.7	5.90	.26	55.2	15	76
1.74	98.1	95.8	98.9	3.91	1.53	51.5	16	
1.47	99.3	87.6	93.5	3.31	1.29	65.5	17	
1.71	98.5	98.2	92.7	3.25	1.03	53.3	18	

SULFUR BALANCE

FINAL CØAL %S	PYRITIC LØSS MM S	TØLUENE EXTRACT MM S	SULFATE MM SØ4	TØTAL RECØVERED MM S	SULFUR BALANCE %	SULFATE SULFUR	J	Run
2.68	30.8	6.4	7.8	76.2	76.5	1.22	1	64
2.61	32.2	23.4	8.2	0.0	0.0	.35	2	65
3.11	19.3	8.1	9.2	95.0	94.3	1.14	3	66
3.15	18.1	6.8	3.8	90.4	90.7	.56	4	67
2.64	28.7	10.7	12.3	84.1	93.8	1.15	5	68
2.78	27.5	7.6	9.7	85.8	88.2	1.28	6	69
2.74	26.9	13.0	14.7	91.1	99.3	1.13	7	70
2.95	21.5	7.5	14.9	91.2	100.1	1.99	8	71
2.73	27.7	9.2	18.0	0.0	0.0	1.96	9	72
2.91	23.6	5.8	17.4	0.0	0.0	2.98	10	73
2.99	20.0	7.7	10.7	85.4	95.9	1.39	11	66
3.11	19.3	8.1	9.2	95.0	94.3	1.14	12	67
3.15	18.1	6.8	3.8	90.4	90.7	.56	13	76
3.03	22.8	6.7	8.2	98.0	92.2	1.22	14	75
2.89	26.4	20.7	5.3	0.0	0.0	.26	15	76
2.95	21.5	7.3	11.2	87.3	95.8	1.53	16	
2.72	31.5	10.2	13.2	92.4	87.6	1.29	17	
2.92	25.7	14.6	15.1	103.2	98.2	1.03	18	

INITIAL SULFUR=3.80%, INITIAL PYRITIC SULFUR=1.65%

ASH DATA

BTU DATA

ASH LØSS ABS %	ASH LØSS REL %	ASH FINAL %	ASH(EXPT) ASH(CALC)	FINAL BTU	BTU CHANGE REL %	BTU-ASH FREE	BTU-ASH FREE REL %	J	Run
1.26	12.2	9.05	.89	12560	-.96	14046	100.0	1	64
.68	6.6	9.63	.45	12403	-2.17	13963	99.5	2	65
2.21	21.4	8.10	2.54	12311	-2.88	13598	96.9	3	66
2.12	20.6	8.19	2.59	12448	-1.83	13761	98.0	4	67
2.18	21.1	8.13	1.49	12453	-1.79	13789	98.2	5	68
2.22	21.5	8.09	1.73	12350	-2.58	13660	97.3	6	69
2.45	23.8	7.86	1.83	12389	-2.28	13671	97.4	7	70
1.77	17.2	8.54	1.65	12416	-2.07	13790	98.2	8	71
1.66	16.1	8.65	1.23	12416	-2.07	13820	98.4	9	72
2.29	22.2	8.02	2.04	12453	-1.79	13756	98.0	10	73
1.68	16.3	8.63	1.65	12374	-2.40	13754	98.0	11	66
2.21	21.4	8.10	2.54	12311	-2.88	13598	96.9	12	67
2.12	20.6	8.19	2.59	12448	-1.83	13761	98.0	13	76
1.13	11.0	9.18	1.16	12164	-4.02	13599	96.9	14	75
-.29	-2.8	10.60	-.25	12176	-3.93	13838	98.6	15	76
1.86	18.0	8.45	1.74	12414	-2.09	13774	98.1	16	
2.00	19.4	8.31	1.47	12573	-.86	13944	99.3	17	
1.90	18.4	8.41	1.71	12468	-1.67	13830	98.5	18	

INITIAL ASH=10.31%, INITIAL BTU=12684, INITIAL ASH FREE BTU=14039

IRØN BALANCE

FE3 INITIAL MM	FE2 FINAL MM	FE3 USED %	FE2 CALC MM	FE2(EXPT) FE2(CALC)	J	Run
524	365	66.7	68	5.36	1	64
481	361	71.7	97	3.74	2	65
480	440	89.7	81	5.42	3	66
471	374	77.5	39	9.66	4	67
420	457	105.4	108	4.22	5	68
472	485	99.8	84	5.76	6	69
524	546	101.6	130	4.21	7	70
371	403	105.7	123	3.28	8	71
421	517	119.5	149	3.48	9	72
443	353	77.0	139	2.53	10	73
394	337	83.0	92	3.67	11	66
480	440	89.7	81	5.42	12	67
471	374	77.5	39	9.66	13	76
538	478	86.7	72	6.68	14	75
520	418	77.8	71	5.90	15	76
403	371	89.4	95	3.91	16	
573	378	63.2	114	3.31	17	
573	439	74.4	135	3.25	18	

CØAL MATERIAL BALANCE

INITIAL WEIGHT G	FINAL WEIGHT G	PYRITE REMØVED G	TØTAL WEIGHT G	RECØVERY %	J	Run
83.9	74.0	1.8	75.8	90.3	1	64
82.5	81.8	1.8	83.6	101.4	2	65
84.8	79.9	1.1	81.0	95.5	3	66
84.0	81.1	1.0	82.1	97.8	4	67
75.5	74.1	1.6	75.7	100.3	5	68
81.9	78.8	1.6	80.4	98.1	6	69
77.3	74.1	1.5	75.6	97.8	7	70
76.7	74.6	1.2	75.8	98.9	8	71
78.7	76.1	1.6	77.7	98.7	9	72
80.5	77.3	1.3	78.6	97.7	10	73
75.0	71.7	1.1	72.8	97.1	11	66
84.8	79.9	1.1	81.0	95.5	12	67
84.0	81.1	1.0	82.1	97.8	13	76
89.5	87.8	1.3	89.1	99.5	14	75
88.2	88.2	1.5	89.7	101.7	15	76
76.7	74.6	1.2	75.8	98.9	16	
88.8	81.2	1.8	83.0	93.5	17	
88.5	80.6	1.5	82.1	92.7	18	

APPENDIX A-3. FERRIC SULFATE EXPERIMENTATION.

Reaction conditions for triplicate runs:

a) 225 mM 0.375M ferric sulfate (600 ml) per 90-100 g coal

530 mM 0.375 M ferric sulfate (1.2 ℓ) per 90-100 g Lower Kittanning Coal

b) 2.0 hour reaction time

c) Coal filtered, washed and extracted 1 hour with 300 ml toluene, then dried at 150-170°C under vacuum.

LØWER KITTANNING CØAL

INITIAL ASH=20.77%, INITIAL BTU=12140, INITIAL ASH FREE BTU=15069

INITIAL SULFUR=4.29%, INITIAL PYRITIC SULFUR=3.58%

DATA SUMMARY

SULFUR CLØSURE %	MATERIAL CLØSURE %	FE2(EXPT) FE2(CALC)	SULFATE SULFUR	SULFUR REMØVED %	J
0.0	98.4	1.25	1.22	35.5	1
0.0	98.5	1.05	1.53	38.8	2
0.0	88.4	1.21	1.33	39.7	3

SULFUR BALANCE

FINAL CØAL %S	PYRITIC LØSS MM S	TØLUENE EXTRACT MM S	SULFATE MM S04	TØTAL RECØVERED MM S	SULFUR BALANCE %	SULFATE SULFUR	J
3.02	36.7	16.4	20.0	0.0	0.0	1.22	1
2.90	40.3	15.8	24.1	0.0	0.0	1.53	2
2.87	41.4	16.5	22.0	0.0	0.0	1.33	3

INITIAL SULFUR=4.29%, INITIAL PYRITIC SULFUR=3.58%

IRØN BALANCE

FE3 INITIAL MM	FE2 FINAL MM	FE3 USED %	FE2 CALC MM	FE2(EXPT) FE2(CALC)	J
467	218	42.8	174	1.25	1
467	214	41.5	205	1.05	2
467	230	44.8	190	1.21	3

CØAL MATERIAL BALANCE

INITIAL WEIGHT G	FINAL WEIGHT G	PYRITE REMØVED G	TØTAL WEIGHT G	RECØVERY %	J
87.5	84.0	2.1	86.1	98.4	1
88.0	84.4	2.3	86.7	98.5	2
88.5	75.9	2.4	78.3	88.4	3

ILLINØIS #5 CØAL

INITIAL ASH=10.96%, INITIAL BTU=12801, INITIAL ASH FREE BTU=14278

INITIAL SULFUR=3.48%, INITIAL PYRITIC SULFUR=1.57%

DATA SUMMARY

SULFUR CLØSURE %	MATERIAL CLØSURE %	FE2(EXPT) FE2(CALC)	SULFATE SULFUR	SULFUR REMØVED %	J
0.0	82.9	1.81	2.29	43.9	1
0.0	97.8	1.43	4.31	45.9	2
0.0	97.3	1.72	3.55	38.9	3

SULFUR BALANCE

FINAL CØAL %S	PYRITIC LØSS MM S	TØLUENE EXTRACT MM S	SULFATE MM SØ4	TØTAL RECØVERED MM S	SULFUR BALANCE %	SULFATE SULFUR	J
2.79	21.1	5.6	12.9	0.0	0.0	2.29	1
2.76	21.1	3.9	16.8	0.0	0.0	4.31	2
2.87	17.2	3.7	13.1	0.0	0.0	3.55	3

INITIAL SULFUR=3.48%, INITIAL PYRITIC SULFUR=1.57%

ASH DATA / BTU DATA

ASH LØSS ABS %	ASH LØSS REL %	ASH FINAL %	ASH(EXPT) ASH(CALC)	FINAL BTU	BTU CHANGE REL %	BTU-ASH FREE	BTU-ASH FREE REL %	J
								1
								2
								3

INITIAL ASH=10.96%, INITIAL BTU=12801, INITIAL ASH FREE BTU=14278

IRØN BALANCE

FE3 INITIAL MM	FE2 FINAL MM	FE3 USED %	FE2 CALC MM	FE2(EXPT) FE2(CALC)	J
226	190	79.4	105	1.81	1
226	189	79.0	132	1.43	2
226	179	75.4	104	1.72	3

CØAL MATERIAL BALANCE

INITIAL WEIGHT G	FINAL WEIGHT G	PYRITE REMØVED G	TØTAL WEIGHT G	RECØVERY %	J
93.0	75.9	1.2	77.1	82.9	1
89.1	85.9	1.2	87.1	97.8	2
85.6	82.3	1.0	83.3	97.3	3

PITTSBURGH CØAL

INITIAL ASH=22.73%, INITIAL BTU=11493, INITIAL ASH FREE BTU=14787

INITIAL SULFUR=1.88%, INITIAL PYRITIC SULFUR=1.20%

DATA SUMMARY

SULFUR CLØSURE %	MATERIAL CLØSURE %	FE2(EXPT) FE2(CALC)	SULFATE SULFUR	SULFUR REMØVED %	J
0.0	99.0	2.02	1.73	25.8	1
0.0	98.2	1.25	2.26	40.0	2
0.0	96.5	1.19	2.47	34.2	3

SULFUR BALANCE

FINAL CØAL %S	PYRITIC LØSS MM S	TØLUENE EXTRACT MM S	SULFATE MM S04	TØTAL RECØVERED MM S	SULFUR BALANCE %	SULFATE SULFUR	J
1.57	10.4	3.8	6.6	0.0	0.0	1.73	1
1.40	16.2	4.9	11.1	0.0	0.0	2.26	2
1.47	13.9	3.9	9.6	0.0	0.0	2.47	3

INITIAL SULFUR=1.88%, INITIAL PYRITIC SULFUR=1.20%

IRØN BALANCE

FE3 INITIAL MM	FE2 FINAL MM	FE3 USED %	FE2 CALC MM	FE2(EXPT) FE2(CALC)	J
226	111	46.8	55	2.02	1
226	113	46.4	91	1.25	2
226	93	38.1	78	1.19	3

CØAL MATERIAL BALANCE

INITIAL WEIGHT G	FINAL WEIGHT G	PYRITE REMØVED G	TØTAL WEIGHT G	RECØVERY %	J
104.7	103.0	.6	103.6	99.0	1
105.2	102.4	.9	103.3	98.2	2
105.5	101.0	.8	101.8	96.5	3

HERRIN #6 CØAL

INITIAL ASH=10.31%, INITIAL BTU=12684, INITIAL ASH FREE BTU=14039

INITIAL SULFUR=3.80%, INITIAL PYRITIC SULFUR=1.65%

DATA SUMMARY

MATERIAL CLØSURE %	FE2(EXPT) FE2(CALC)	SULFATE SULFUR	SULFUR REMØVED %	J
97.7	2.20	5.94	35.8	1
97.9	3.78	1.27	24.2	2
98.6	2.33	2.02	32.7	3

SULFUR BALANCE

FINAL CØAL %S	PYRITIC LØSS MM S	TØLUENE EXTRACT MM S	SULFATE MM SØ4	TØTAL RECØVERED MM S	SULFUR BALANCE %	SULFATE SULFUR	J
3.21	16.3	2.3	13.7	0.0	0.0	5.94	1
3.40	11.0	4.8	6.1	0.0	0.0	1.27	2
3.26	14.9	4.9	9.9	0.0	0.0	2.02	3

INITIAL SULFUR=3.80%, INITIAL PYRITIC SULFUR=1.65%

IRØN BALANCE

FE3 INITIAL MM	FE2 FINAL MM	FE3 USED %	FE2 CALC MM	FE2(EXPT) FE2(CALC)	J
226	233	99.5	106	2.20	1
226	200	86.1	53	3.78	2
226	190	80.8	81	2.33	3

CØAL MATERIAL BALANCE

INITIAL WEIGHT G	FINAL WEIGHT G	PYRITE REMØVED G	TØTAL WEIGHT G	RECØVERY %	J
83.3	80.5	.9	81.4	97.7	1
83.0	80.6	.6	81.2	97.9	2
83.3	81.3	.8	82.1	98.6	3

```
      PROGRAM COAL5 (INPUT,OUTPUT,TAPE8,TAPE6)
      DIMENSION ASH(50),SAP(50)
C     ONE COAL PER RUN
C     DIMENSION STATEMENTS FOR PROGRAM VARIABLES
     1 DIMENSION SF(50),ASHF(50),BTUF(50),FE2F(50),FE3IN(50)
     2 DIMENSION CF(50),CI(50),AMS(50), AMSO4(50),AMCSO4(50),SO4F(50)
     3 DIMENSION SPLOSS(50),ASHLOSS(50),BTUGAIN(50),SAHLOSS(50),ASHR(50),
      1ASHREL(50),BTUFAC(50),FES2REM(50),CFT(50),TOTREC(50),XMATCLS(50),
      2AMSF(50),AMSI(50),AMPLOSS(50),AMFS(50),SULSUM(50),SBAL(50)
     4 DIMENSION SO4RAT(50),BTU(50),BTUREL(50),BTUCOR(50),AMFE2(50),FE3US
      1ED(50),SPREM(50),FERATIO(50),BTUCORF(50),FE2MM(50),RATIOFE(50),
      2TOLEXT(50),ASHW(50),RATIO(50),SO4(50),STREM(50),STLOSS(50)
C      INPUT VARIABLES-NON SUBSCRIPTED.  ONLY ONE COAL PER RUN.
C     SI=INITIAL SULFUR,ASHI=INITIAL ASH,BTUI=INITIAL BTU,SP=INITIAL
C     PYRITIC SULFUR, SO4I=INITIAL SULFATE SULFUR
    10 REWIND 8
      REWIND 6
      PRINT 7
     7 FORMAT (*CHOOSE TYPE OF OUTPUT.*/*1=PRINTOUT, 2=PRINTOUT*
      1* AND TAPE, 3=TAPE.*)
C     MFLAG=TYPE OF OUTPUT
C     NFLAG=TABLE FOR PRINTOUT
      ACCEPT MFLAG
      PRINT 8
     8 FORMAT (*TYPE K,L*/*K=BEGINING RUN #, L=ENDING RUN #*)
      ACCEPT K,L
      NFLAG=2
      IF (MFLAG-3)  5,6,6
     5 PRINT 9
     9 FORMAT (*CHOOSE TABLE*/*1=SUMMARY, 2=SULFUR, 3=ASH,BTU,*
      1* 4=IRON, 5=COAL*)
      ACCEPT NFLAG
     6 ACCEPT (8) I
    11 ACCEPT(8) SI,SP,ASHI,BTUI,SO4I
C     INPUT VARIABLES-SUBSCRIPTED
C     J=SUBSCRIPT-NUMBER OF RUNS,SF=FINAL SULFUR,ASHF=FINAL ASH,BTUF=
C     FINAL BTU,CI=INITIAL COAL WT.,CF=FINAL COAL WT.,FE2F=FINAL FE(2),
C     FE3IN=INITIAL FE(3). COAL IS DRY WEIGHT. IRON IS IN MM.
      PRINT 700
      PRINT 700
      IF (NFLAG-2) 1411,1511,1511
 1411 PRINT 200
```

```
 1511 DO 13 J=I,L
   12 ACCEPT  (8) SF(J),SO4F(J),ASHF(J),BTUF(J),CI(J),CF(J),FE3IN(J),
     1FE2F(J),AMS(J),TOLEXT(J)
   13 CONTINUE
C     COMPUTATION OF SULFUR,ASH AND BTU CHANGE AND ASH BALANCE
   20 DO 100 J=K,L
      SO4(J)=SO4F(J)-SO4I
      STLOSS(J)=SI-SF(J)
   21 SPLOSS(J)=SI-(SF(J)-SO4(J))
   22 ASHLOSS(J)=ASHI-ASHF(J)
   23 BTUGAIN(J)=-(BTUI-BTUF(J))
C     SAHLOSS=ASH LOSS CALCULATED FROM PYRITIC SULFUR LOSS IN PERCENT
C     MINUS SULFATE ASH ADDED TO THE COAL
   24 SAHLOSS(J)=SPLOSS(J)*1.26
   25 ASHR(J)=ASHLOSS(J)/SAHLOSS(J)
C     ASHR=(ACTUAL ASH LOSS)/(ASH LOSS CALCULATED FROM SULFUR LOSS)
   26 ASHREL(J)=(ASHLOSS(J)/ASHI)*100.
C     ASHREL= PERCENT OF TOTAL ASH THAT IS REMOVED
C     BTUFAC=IF ASH LOSS IS LESS THAN CALCULATED, THE FINAL BTU VALUE IS
C     CORRECTED BY THIS VALUE
   27 BTUFAC(J)=(100.-(SAHLOSS(J)-ASHLOSS(J)))/100.
   28 IF(1.0-BTUFAC(J))  29,30,30
   29 BTUFAC(J)=1.0
C     CALCULATION OF MATERIAL BALANCE
C     FES2REM=WT. PYRITE REMOVED
C     CFT=FINAL COAL WEIGHT IF ONLY PYRITE IS REMOVED
   30 FES2REM(J)=SPLOSS(J)*CI(J)/(55.85-SF(J))
      ASHW(J)=SAHLOSS(J)*(ASHR(J)-1.)*CI(J)/100.
C     ASHW=WEIGHT OF EXCESS ASH REMOVED
      IF(ASHR(J).LT.1.0) ASHW(J)=0.0
   31 CFT(J)=CI(J)-FES2REM(J)
C     TOTREC=TOTAL ACCOUNTABLE WEIGHT
C     MATCLOS=PERCENT MASS ACCOUNTED FOR
C     AVERAGE WEIGHT OF COAL IN THE FILTER PAPER IS 0.1G.
   32 TOTREC(J)=CF(J)+FES2REM(J)+ASHW(J)+TOLEXT(J)-(SO4(J)*CF(J)*.0531)
   33 XMATCLS(J)=(TOTREC(J)/CI(J))*100.
C     CALCULATION OF SULFUR BALANCE
C     AMSF=MMOLES SULFUR AFTER TREATMENT IN THEORY
C     AMSI=MMOLES SULFUR IN STARTING COAL
C     AMPLOSS=MMOLOES PYRITIC SUFUR LOST BASED ON SULFUR LOSS ANALYSIS
C     AMFS=MMOLES SULFUR IN FINAL COAL
C     AMCSO4=MMSULFATE SULFUR ADDED TO THE COAL
```

```
   40 AMSF(J)=(CFT(J)*SF(J))/3.2
   41 AMSI(J)=(CI(J)*SI)/3.2
      AMCSO4(J)=(CFT(J)*SO4(J))/3.2
   42 AMPLOSS(J)=AMSI(J)-AMSF(J)+AMCSO4(J)
   43 AMFS(J)=(CF(J)*SF(J))/3.2
   44 SULSUM(J)=AMFS(J)+AMS(J)+AMSO4(J)
   45 SBAL(J)=(SULSUM(J)/AMSI(J))*100.
   47 IF(AMS(J).EQ.0) SBAL(J)=0.0
   48 IF(AMS(J))      49,49,50
   49 AMS(J)=(AMPLOSS(J)-AMSO4(J))*(XMATCLS(J)/100.)
      SULSUM(J)=0.0
   50 IF (AMSO4(J)) 490,490,491
  490 SBAL(J)=0.0
      SULSUM(J)=0.0
      AMSO4(J)=(AMPLOSS(J)-AMS(J))*(XMATCLS(J)/100.)
  491 SO4RAT(J)=AMSO4(J)/AMS(J)
   54 SPREM(J)=(SPLOSS(J)/SP)*100.
      STREM(J)=STLOSS(J)/SP*100.
C     COMPUTATION OF BTU BALANCE
C     BTU=BTU CHANGE,BTUREL=PERCENT CHANGE,BTUCOR=PERCENT CHANGE CORRECT
C     ED FOR ASH AND PYRITE REMOVAL
C     SEE 23
   51 BTUREL(J)=(BTUGAIN(J)/BTUI)*100.
      BTUCORI=((BTUI-(SP*0.01*1.871*2995.))/(100.-ASHI))*100.
      BTUCORF(J)=((BTUF(J)-((SP-SPLOSS(J))*0.01*1.871*2995.))/(100.-ASHF
     1(J)))*100.
      BTUCOR(J)=(BTUCORF(J)/BTUCORI)*100.
C     COMPUTATION OF IRON BABANCE
   60 AMFE2(J)=AMPLOSS(J)*5.00
   61 FE3USED(J)= ((FE2F(J)-(AMPLOSS(J)/2.))/FE3IN(J))*100.
   62 FERATIO(J)=FE2F(J)/AMFE2(J)
      FE2MM(J)=AMPLOSS(J)*1.5
   64 RATIOFE(J)=FE2F(J)/FE2MM(J)
      RATIO(J)=FE2F(J)/AMPLOSS(J)
      IF (NFLAG-2) 63,100,100
   63 PRINT 202, ASHR(J),BTUCOR(J),XMATCLS(J),
     1RATIO(J),STREM(J),SPREM(J),J
  100 CONTINUE
  700 FORMAT (3(/))
C     DATA SUMMARY OUTPUT
  200 FORMAT  (28X*DATA SUMMARY*//51X*PYRITIC*/
     1*ASH(EXPT)  BTU-ASH  MATERIAL  MM FE2/*5X*SULFUR*
```

```
     23X*SULFUR*7*ASH(CALC)  FREE*5X*CLOSURE*3X*MM SULFUR*
     33X*REMOVED*2X*REMOVED*/14X*≤*9X*≤*6X*REMOVED*7X*≤*15X*J*)
  202 FORMAT (F7.2,F9.1,F10.1,F11.2,F10.2,F9.1,I6)
      IF (I-2) 14,15,16
   16 IF (I-4) 17,18,19
   14 PRINT 140
      GO TO 191
   15 PRINT 150
      GO TO 191
   17 PRINT 170
      GO TO 191
   18 PRINT 180
      GO TO 191
   19 PRINT 190
  140 FORMAT (/*LOWER KITTANNING COAL*)
  150 FORMAT (/*ILLINOIS #5 COAL*)
  170 FORMAT (/*PITTSBURGH COAL*)
  180 FORMAT (/*HERRIN #6 COAL*)
  190 FORMAT (/*SPECIAL COAL*)
  191 PRINT 900, ASHI,BTUI,BTUCORI
  192 PRINT 800, SI,SP,SO4I
      IF (MFLAG-2) 801,801,802
  801 IF (NFLAG-4) 2001,299,306
 2001 IF (NFLAG-2) 901,499,810
C     IRON BALANCE OUTPOUT
  299 PRINT 700
      PRINT 300
  300 FORMAT (26X*IRON BALANCE*//*FE3*6X*FE2*4X*FE3*4X*FE2*4X*FE2(EXPT)*
     12X*FE2(EXPT)*2X*MM FE2/*/*INITIAL  FINAL  USED  CALC  FE2(CALC-*
     22X*FE2(CALC-*2X*MM SULFUR*/
     32X*MM*6X*MM*6X*≤*5X*MM*4X*SULFATE)*3X*SULFUR)*4X*REMOVED*5X*J*)
  301 DO 305 J=K,L
      PRINT 302, FE3IN(J),FE2F(J),FE3USED(J),AMFE2(J),FERATIO(J),
     1RATIOFE(J),RATIO(J),J
  302 FORMAT (F5.0,F8.0,F7.1,F6.0,F10.2,2F11.2,I7)
  305 CONTINUE
      GO TO 901
  306 PRINT 700
C     MATERIAL BALANCE-COAL OUTPUT
      PRINT 400
  400 FORMAT (21X*COAL MATERIAL BALANCE*//*INITIAL  FINAL    PYRITE*
     14X*EXCESS*2X*TOLUENE*2X*TOTAL*4X*RECOVERY*/
```

```
     2*WEIGHT*3X*WEIGHT*3X*REMOVED*3X*ASH*5X*EXTRACT*2X*WEIGHT*/
     33X*G*8X*G*8X*G*8X*G*8X*G*8X*G*8X*G*8X*≤*8X*J*)
  401 DO 405 J=K,L
  402 PRINT 403, CI(J),CF(J),FES2REM(J),ASHW(J),TOLEXT(J),
     1TOTREC(J),XMATCLS(J),J
  403 FORMAT (F5.1,6F9.1,I8)
  405 CONTINUE
      PRINT 700
      GO TO 901
C     SULFUR BALANCE OUTPUT
  499 PRINT 700
      PRINT 500
  500 FORMAT (19X*SULFUR BALANCE*//X*FINAL  FINAL  PYRITIC  TOLUENE*
     12X*SULFATE  SULFATE*/X*COAL*3X*COAL*3X*LOSS     EXTRACT*2X*CALC.*
     24X*SULFUR*/2X*≤S*4X*≤ SO4*2X*MM S*5X*MM S*5X*MM SO4*14X*J*)
     3 S* 8X*≤*16X*J*)
  501 DO 505 J=K,L
  502 PRINT 503, SF(J),SO4F(J),AMPLOSS(J),AMS(J),AMSO4(J),
     1SO4RAT(J),J
  503 FORMAT (F5.2,F7.2,F8.1,2F9.1,F9.2,I7)
  505 CONTINUE
  800 FORMAT(/*INITIAL SULFUR=*F4.2,*≤,*X
     1*INITIAL PYRITIC SULFUR=*,F4.2,*≤*//
     2*INITIAL SULFATE SULFUR=*,F4.2,*≤*)
C     OUTPUT - BTU AND ASH DATA
      GO TO 901
  810 PRINT 700
      PRINT 600
  600 FORMAT (11X*ASH DATA*23X*BTU DATA*//*ASH*4X*ASH*4X*ASH*4X*ASH(EXPT
     1)*X*FINAL*2X*BTU*5X*BTU-ASH*2X*BTU-ASH*/
     2*LOSS*3X*LOSS*3X*FINAL  ASH(CALC)*1X*BTU*4X*CHANGE*2X*FREE*
     35X*FREE*/*ABS ≤  REL ≤*4X*≤*21X*REL ≤*12X*REL ≤*8X*J*)
  601 DO 605 J=K,L
  602 PRINT 603, ASHLOSS(J),ASHREL(J),ASHF(J),ASHR(J),BTUF(J),
     1BTUREL(J),BTUCORF(J),BTUCOR(J),J
  603 FORMAT (F4.2,F6.1,F9.2,F8.2,4X,F5.0,F7.2,F8.0,F9.1,I9)
  605 CONTINUE
  900 FORMAT (/*INITIAL ASH=*,F5.2,*≤,*X*INITIAL BTU=*,F5.0,*,*
     1 X*INITIAL ASH FREE BTU=*,F5.0)
      PRINT 700
      GO TO 901
  901 IF (MFLAG-2)  1001,802,802
```

```
C       TAPE OUTPUT
C       DATA SUMMARY OUTPUT
  802 WRITE (6,700)
      WRITE (6,200)
 1201 DO 1205 J=K,L
      WRITE (6,202)  ASHR(J),BTUCOR(J),XMATCLS(J),RATIO(J),
     1STREM(J),SPREM(J),J
 1205 CONTINUE
      IF (I-2) 114,115,116
  116 IF (I-4) 117,118,119
  114 WRITE (6,140)
      GO TO 1191
  115 WRITE (6,150)
      GO TO 1191
  117 WRITE (6,170)
      GO TO 1191
  118 WRITE (6,180)
      GO TO 1191
  119 WRITE (6,190)
 1191 WRITE (6,900)  ASHI,BTUI,BTUCORI
 1192 WRITE (6,800)  SI,SP,SO4I
      GO TO 1406
C       IRON BALANCE OUTPOUT
 1193 WRITE (6,700)
      WRITE (6,300)
 1301 DO 1305 J=K,L
      WRITE (6,302)  FE3IN(J),FE2IN(J),FE3USED(J),AMFE2(J),FERATIO(J),
     1RATIOFE(J),RATIO(J),J
 1305 CONTINUE
      WRITE (6,700)
C       MATERIAL BALANCE-COAL OUTPUT
      WRITE (6,400)
 1401 DO 1405 J=K,L
 1402 WRITE (6,403) CI(J),CF(J),FES2REM(J),ASHW(J),TOLEXT(J),
     1TOTREC(J),XMATCLS(J),J
 1405 CONTINUE
      GO TO 1606
 1406 WRITE (6,700)
C       SULFUR BALANCE OUTPU.
      WRITE (6,500)
 1501 DO 1505 J=K,L
 1502 WRITE (6,503) SF(J),SO4F(J),AMPLOSS(J),AMS(J),AMSO4(J),
```

```
     1SO4RAT(J),J
  1505 CONTINUE
       WRITE (6,800) SI,SP,SO4I
C      OUTPUT - BTU AND ASH DATA
       WRITE (6,700)
       WRITE (6,600)
  1601 DO 1605 J=K,L
  1602 WRITE (6,603) ASHLOSS(J),ASHREL(J),ASHF(J),ASHR(J),BTUF(J),
      1BTUREL(J),BTUCORF(J),BTUCOR(J),J
  1605 CONTINUE
       WRITE (6,900) ASHI,BTUI,BTUCORI
       GO TO 1193
  1606 WRITE (6,700)
       WRITE (6,700)
       PRINT 1002
       PRINT 1002
       PRINT 1000
  1000 FORMAT (*DO YOU WISH TO SAVE TAPE 6 ≥*)
  1001 PRINT 1002
  1002 FORMAT (///)
       END
```

APPENDIX A-5. IN SITU REGENERATION OF FERRIC SULFATE LEACH SOLUTION

Nominal Reaction Conditions:

a) 100g -100 mesh Illinois #5 coal

b) 2.4 liters 1.0N ferric sulfate solution, 0.05M in copper sulfate

c) 4.0 hours reaction time, plus 40 min. warm-up with no gas flow

d) Reaction temperature 95°

e) Oxygen or nitrogen flow rate 200 ml/min through a fine (4-5.5) fritted glass disc)

f) Coal filtered, washed 4 times on filter funnel, slurried at least 1 hour at 80°; filtered dry, then extracted twice for 3/4 hour with 300 ml toluene at reflux

g) Dried overnight at 150 - 170°C and cooled under vacuum

Specific Reaction Conditions:

Index (J)	Variable Change
1,2	No catalyst, nitrogen flow
3,4	No catalyst, oxygen flow
5,6	Nominal, 95°
7,8	50 ml/min oxygen flow
9,10	Nominal, 65°
11,12	Medium frit
13,14	Nominal, 50°
15,16	Nominal, 80°

ASH DATA

BTU DATA

ASH LØSS ABS %	ASH LØSS REL %	ASH FINAL %	ASH(EXPT) ASH(CALC)	FINAL BTU	BTU CHANGE REL %	BTU-ASH FREE	BTU-ASH FREE REL %	J
2.66	24.3	8.30	2.01	12781	-.16	13906	97.4	1
2.91	26.6	8.05	2.08	12845	.34	13942	97.6	2
2.65	24.2	8.31	1.91	12703	-.77	13826	96.8	3
2.68	24.5	8.28	1.93	12599	-1.58	13708	96.0	4
2.54	23.2	8.42	1.85	12804	.02	13952	97.7	5
2.29	20.9	8.67	1.87	12605	-1.53	13765	96.4	6
2.61	23.8	8.35	1.85	12849	.37	13992	98.0	7
2.35	21.4	8.61	1.76	12873	.56	14055	98.4	8
2.55	23.3	8.41	1.73	12713	-.69	13856	97.0	9
2.47	22.5	8.49	1.92	12565	-1.84	13697	95.9	10
2.72	24.8	8.24	2.00	12841	.31	13964	97.8	11
2.62	23.9	8.34	1.81	12572	-1.79	13690	95.9	12
1.97	18.0	8.99	2.30	12755	-.36	13960	97.8	13
1.96	17.9	9.00	2.05	12715	-.67	13923	97.5	14
2.60	23.7	8.36	2.11	12761	-.31	13889	97.3	15
2.55	23.3	8.41	1.78	12836	.27	13988	98.0	16

INITIAL ASH=10.96%, INITIAL BTU=12801, INITIAL ASH FREE BTU=14278

IRØN DATA

FE3 INITIAL MM	FE2 FINAL MM	FE3 USED %	FE2 CALC MM	FE2(EXPT) FE2(CALC-SULFATE)	FE2(EXPT) FE2(CALC-SULFUR)	MM FE2/ MM SULFUR REMØVED	J
2246	419	18.0	151	2.77	9.22	13.83	1
2436	413	16.3	151	2.74	9.13	13.70	2
2246	374	15.9	159	2.36	7.86	11.79	3
2680	330	11.8	142	2.33	7.75	11.63	4
2246	334	14.2	150	2.22	7.41	11.12	5
2246	300	12.8	134	2.24	7.46	11.20	6
2436	411	16.3	151	2.72	9.08	13.61	7
2680	342	12.2	155	2.21	7.37	11.06	8
2436	185	6.9	159	1.17	3.89	5.84	9
2680	159	5.4	151	1.05	3.50	5.26	10
2680	344	12.2	165	2.09	6.96	10.44	11
2680	338	12.0	165	2.05	6.83	10.24	12
2361	107	4.1	93	1.15	3.84	5.76	13
2361	78	2.9	101	.77	2.56	3.84	14
2361	114	4.3	132	.86	2.87	4.30	15
2361	187	7.3	152	1.23	4.10	6.16	16

DATA SUMMARY

ASH(EXPT) ASH(CALC)	BTU-ASH FREE %	MATERIAL CLOSURE %	MM FE2/ MM SULFUR REMOVED	INORGANIC SULFUR REMOVED %	PYRITIC SULFUR REMOVED %	J
2.01	97.4	92.8	13.83	52.9	66.9	1
2.08	97.6	98.1	13.70	59.2	70.7	2
1.91	96.8	96.4	11.79	54.8	70.1	3
1.93	96.0	99.3	11.63	58.6	70.1	4
1.85	97.7	102.2	11.12	52.9	69.4	5
1.87	96.4	91.2	11.20	46.5	61.8	6
1.85	98.0	101.8	13.61	52.9	71.3	7
1.76	98.4	91.4	11.06	52.2	67.5	8
1.73	97.0	104.9	5.84	58.0	74.5	9
1.92	95.9	101.6	5.26	46.5	65.0	10
2.00	97.8	97.2	10.44	57.3	68.8	11
1.81	95.9	98.5	10.24	56.7	73.2	12
2.30	97.8	101.0	5.76	37.6	43.3	13
2.05	97.5	99.1	3.84	43.3	48.4	14
2.11	97.3	89.7	4.30	57.3	62.4	15
1.78	98.0	100.0	6.16	65.6	72.6	16

ILLINOIS #5 COAL

INITIAL ASH=10.96%, INITIAL BTU=12801, INITIAL ASH FREE BTU=14278

INITIAL SULFUR=3.48%, INITIAL PYRITIC SULFUR=1.57%

INITIAL SULFATE SULFUR= .05%

SULFUR DATA

FINAL COAL %S	FINAL COAL % SO4	PYRITIC LOSS MM S	TOLUENE EXTRACT MM S	SULFATE CALC. MM SO4	SULFATE SULFUR	J
2.65	.27	30.3	8.0	20.7	2.59	1
2.55	.23	30.1	8.4	21.3	2.54	2
2.62	.29	31.7	8.8	22.1	2.51	3
2.56	.23	28.4	7.1	21.1	2.97	4
2.65	.31	30.0	9.9	20.6	2.08	5
2.75	.29	26.8	8.2	17.0	2.07	6
2.65	.34	30.2	10.7	19.8	1.85	7
2.66	.29	30.9	4.6	24.1	5.23	8
2.57	.31	31.7	5.4	27.6	5.11	9
2.75	.34	30.2	8.2	22.4	2.73	10
2.58	.23	32.9	4.2	27.9	6.65	11
2.59	.31	33.0	7.6	25.0	3.29	12
2.89	.14	18.6	1.3	17.5	13.43	13
2.80	.13	20.3	3.5	16.6	4.76	14
2.58	.13	26.5	3.9	20.2	5.19	15
2.45	.16	30.4	7.5	22.9	3.05	16

INITIAL SULFUR=3.48%, INITIAL PYRITIC SULFUR=1.57%

INITIAL SULFATE SULFUR= .05%

COAL MATERIAL BALANCE

INITIAL WEIGHT G	FINAL WEIGHT G	PYRITE REMOVED G	EXCESS ASH G	TOLUENE EXTRACT G	TOTAL WEIGHT G	RECOVERY %	J
88.3	78.3	1.7	1.2	1.6	81.9	92.8	1
83.2	77.4	1.7	1.3	2.0	81.7	98.1	2
86.3	81.5	1.8	1.1	1.7	85.1	96.4	3
79.0	74.6	1.6	1.0	1.9	78.4	99.3	4
84.4	82.8	1.7	1.0	1.9	86.3	102.2	5
84.4	74.4	1.5	.9	1.1	77.0	91.2	6
82.6	80.6	1.7	1.0	2.0	84.1	101.8	7
89.3	78.0	1.8	.9	1.9	81.6	91.4	8
83.1	84.2	1.8	.9	1.4	87.2	104.9	9
90.7	88.6	1.7	1.1	2.1	92.2	101.6	10
93.4	86.2	1.9	1.3	2.2	90.7	97.2	11
88.0	82.9	1.9	1.0	2.0	86.7	98.5	12
83.1	79.6	1.1	.9	2.7	83.9	101.0	13
81.3	77.0	1.2	.8	1.9	80.6	99.1	14
82.6	68.7	1.5	1.1	3.0	74.1	89.7	15
81.7	76.9	1.7	.9	2.6	81.7	100.0	16

APPENDIX "B"

BENCH-SCALE EXPERIMENTATION

TABLE B-1. PYRITIC SULFUR REMOVAL FROM COAL WITH FERRIC CHLORIDE - FERRIC ION AND COAL WEATHERING EFFECTS

Part I. - Summary of Experimental Conditions.

Exp. No.	EXPERIMENTAL PARAMETERS								SULFUR RECOVERY Toluene Reflux			
	Type of Coal	Top Size	Molarities and Reagents Used	Reaction		Filtration Time (Minutes)	Washing				Coal Drying	
				Time (Hours)	Temp. (°C)		No. of Washes	Water Temp. (°C)	Time (Minutes)	Temp. (°C)	Temp. (°C)	Time (Hours)
20	Lower Kittanning	100 mesh	2.58M $FeCl_3$ +0.10M HCl	4	106	10	4	96	60	84	105	14
21	Lower Kittanning	100 mesh	2.58M $FeCl_3$ +0.10M HCl	4	106	10	4	96	60	84	105	17
22	Lower Kittanning (oxidized)	100 mesh	2.58M $FeCl_3$ +0.10M HCl	4	104	15	6	88	60	84	102	15
23	Lower Kittanning (oxidized)	100 mesh	2.58M $FeCl_3$ +0.10M HCl	4	104	10	6	93	60	84	103	14
24	Illinois No. 5	100 mesh	1.49M $FeCl_3$ +0.10M HCl	4	102	10	9	83	60	84	105	17
25	Illinois No. 5	100 mesh	1.49M $FeCl_3$ +0.10M HCl	4	102	10	6	84	60	84	105	17
26	Illinois No. 5 (oxidized)	100 mesh	1.44M $FeCl_3$ +0.10M HCl	4	104	15	6	80	60	83	105	15
27	Illinois No. 5	100 mesh	1.44M $FeCl_3$ +0.10M HCl	4	103	15	6	75	60	83	105	15

TABLE B-1. CONTINUED

Part II. Process Mass Balance

Exp. No.	WEIGHTS IN GRAMS																
	Coal in (Dry)	Processed Coal (Dry)	Toluene Distillation Residue	Coal Recovered From Filters[a]	Solids Out-In	Reagent Solution In	Wash Water In	Toluene In	Total Liquid Charge	Liquid Out					Total Liquid Out	Liquid Out-In	Net Process Losses
										Reactor Filtrate	Combined Wash[b]	Last Wash	Toluene Distillate	Drier Traps			
20	1066	883	9.3	63.5	-110.2	7550	3911	2584	14045	7001	3001	1145	2252	347	13744	-301	-411
21	992	920	8.5	57.3	- 6.2	7674	4006	2457	14137	6966	3215	873	2230	369	13653	-484	-490
22	1028	959	10.7	67.9	+ 9.6	7701	5938	2650	16289	7105	3095	2804	2317	391	15712	-577	-567
23	960	880	10.6	74.1	+ 4.7	7722	5886	2626	16234	7056	3265	2839	2406	339	15905	-329	-324
24	898	871	7.3	56.7	+ 37.0	7096	10607	2361	20064	6377	3111	7449	2137	548	19622	-442	-405
25	852	837	6.5	48.8	+ 40.3	7052	5775	2232	15059	6477	2911	2785	1991	395	14559	-500	-460
26	778	739	5.2	48.5	+ 14.7	7029	5669	2227	14925	6565	2814	2702	1980	511	14572	-353	-338
27	759	728	6.1	54.8	+ 29.9	7069	5829	2229	15127	6604	2827	2915	1951	465	14762	-365	-335

[a]Weight of coal on filters was added to the weight of dry processed coal for all calculations.
[b]Does not include filtrate of last wash.

TABLE B-1. CONTINUED

Part III. - Analytical Data for Sulfur and Ion Balances.

Exp. No.	ANALYTICAL DATA, WEIGHT PERCENT[c] (ON DRY BASIS FOR SOLIDS)																	
	Heat Content (BTU/Lb)	Ash	Total Sulfur In Coal	Sulfur Forms in Coal			Sulfur as Sulfate In			Sulfur In Toluene Residue	Total Iron In				Fe^{+2}		Nitrogen in Coal
				Pyritic	Sulfate	Organic	Reactor Filtrate	Combined Wash	Last Wash		Fe in Coal	Fe in Reactor Filtrate	Fe in Combined Wash	Fe in Last Wash	Reactor Filtrate	Combined Wash	
20	12,800	16.43	1.91	1.32	0.02	0.57	Taken at 8 times (see separate table)	0.0263	0.6×10^{-3}	82.4	1.48	Taken at 8 times (see separate table)	1.681	4.0×10^{-3}	Taken at 8 times (see separate table)	0.489	NA
21	12,789	16.06	1.82	1.23	0.03	0.56		0.0367	4.5×10^{-3}	82.3	1.47		2.141	1.2×10^{-3}		0.645	NA
22	12,714	16.93	2.01	1.45	0.02	0.54		0.0266	0.4×10^{-3}	79.5	1.66		1.725	5.6×10^{-3}		0.544	NA
23	12,812	15.87	1.58	0.99	0.02	0.57		0.0277	0.7×10^{-3}	79.2	1.31		2.022	6.7×10^{-3}		0.526	NA
24	12,268	9.51	2.58	1.01	0.02	1.55		0.0103	0.2×10^{-3}	34.5	1.57		1.373	8.7×10^{-3}		0.964	NA
25	12,228	9.25	2.58	0.96	0.03	1.59		0.0070	0.2×10^{-3}	36.5	1.54		1.237	9.1×10^{-3}		0.826	NA
26	12,172	9.66	2.48	0.84	0.01	1.63		0.0054	0.2×10^{-3}	35.6	1.50		0.971	21.2×10^{-3}		0.587	NA
27	12,084	9.30	2.43	1.12	0.01	1.30		0.0072	0.2×10^{-3}	34.6	1.46		0.928	16.6×10^{-3}		0.566	NA

[c]Except for heat content

Part IV. - Sulfur Balance and Sulfur Removal Estimates.

Exp. No.	SULFUR BALANCE, GRAMS																		
	Sulfur In			Sulfur Out					Pyritic Sulfur In	Estimated Pyrite Removal From[e]									
	From Coal	From Reagents	Total In	In Processed Coal	In Reactor Filtrate	In Combined Wash	In Last Wash	In Toluene Residue	Sulfur Out-In[d]		Total Sulfur In Coal		Sulfur Forms In Coal		Produced $S_n + SO_4^{-2}$		Produced[f] Sulfate		Produced Elemental Sulfur		SO_4/Sn
											Grams	%	Grams	%	Grams		Grams (as sulfur)	m Moles	Grams	m Moles	
20	44.99	0	44.99	18.08	12.16	0.79	0.01	7.66	-6.29	38.27	26.91	70.3	25.78	67.4	20.62	53.9	12.96	404	7.66	239	1.69
21	41.86	0	41.86	17.78	12.30	1.18	0.04	7.00	-3.56	35.61	24.08	67.6	23.59	66.2	20.51	57.6	13.52	422	7.00	218	1.93
22	43.38	0	43.38	20.64	11.09	0.82	0.01	8.51	-2.31	36.91	22.74	61.6	22.02	59.7	20.43	55.4	11.92	372	8.51	265	1.40
23	40.51	0	40.51	15.07	10.39	0.90	0.02	8.40	-5.73	34.46	25.44	73.8	25.02	72.6	19.71	57.2	11.31	353	8.40	262	1.35
24	31.70	0	31.70	23.93	3.38	0.32	0.01	2.52	-1.84	14.01	7.76	55.4	4.64	33.1	6.23	44.5	3.72	116	2.52	79	1.48
25	30.08	0	30.08	22.85	3.94	0.20	0.01	2.37	-0.70	13.29	7.22	54.3	4.78	36.0	6.52	49.1	4.15	129	2.37	74	1.75
26	27.46	0	27.46	19.53	3.05	0.15	0.01	1.85	-2.87	12.14	7.93	65.3	5.53	45.5	5.06	41.7	3.21	100	1.85	58	1.73
27	26.79	0	26.79	19.02	3.00	0.20	0.01	2.11	-2.45	11.84	7.77	65.6	3.07	26.0	5.32	44.9	3.21	100	2.11	66	1.52

[c]Except for heat content.
[d]Difference between sulfur recovered and sulfur removed according to Eschka analyses of feed and processed coal samples.
[e]Three methods of computing sulfur removal are indicated.
[f]Difference between Sulfate collected and that added to the reactor.

TABLE B-1. CONTINUED

Part V. - Iron Mass Balance Data.

Exp. No.	TOTAL IRON BALANCE, GRAMS								
	Fe In			Fe Out					Δ Fe Out-In
	From Coal	From Reagents	Total In	In Reactor Filtrate	In Combined Wash	In Last Wash	In Processed Coal	Total Out	
20	33.6	833.3	866.9	771.3	50.4	~0.1	14.0	835.8	-31.1
21	31.2	847.0	878.2	760.2	68.8	~0.1	14.4	843.4	-34.8
22	32.4	850.0	882.3	779.2	53.4	0.2	17.0	849.8	-32.5
23	30.2	852.3	882.5	757.4	66.0	0.2	12.5	836.1	-46.4
24	13.7	488.7	502.4	444.1	42.7	0.6	14.5	502.0	- 0.4
25	13.0	485.7	498.7	410.7	36.0	0.3	13.6	460.6	-38.1
26	11.9	475.0	486.9	453.3	27.3	0.6	11.8	493.0	+ 6.1
27	11.6	477.7	489.3	384.0	26.2	0.5	11.4	422.2	-67.1

[g]Assumes that Fe removed from coal was of +2 valence.
[h]The difference between "Fe^{+3} used" and Fe^{+2} produced.
[i]Based on "Fe^{+2} produced".
[j]Based on "Collected Elemental Sulfur and Sulfate".
[k]Excess of calculated "theoretical usage".

Exp. No.	FERRIC AND FERROUS ION BALANCE, GRAMS														
	Fe^{+3} In (Reagents)	Reactor Filtrate	Combined Wash	Total Out	Fe^{+3} Used In-Out	Fe^{+2} In			Fe^{+2} Out		Fe^{+2} Produced Out-In	Unaccounted Fe^{+3}[h]	Moles Fe^{+3} Used[i]	Theoretical Moles Fe^{+3} Used[j]	Percent XS Fe^{+3} Used[k]
						Δ Fe Coal[g]	Reagents	Total In	Reactor Filtrate	Wash Filtrate					
20	833.3	571.5	35.8	607.3	226.0	19.5	0	19.5	199.8	14.7	195.0	-31.0	3.49	3.07	14
21	847.0	554.0	48.1	602.1	244.9	16.9	0	16.9	206.2	20.7	210.0	-34.8	3.77	3.17	19
22	850.0	578.3	36.6	614.9	235.1	15.4	0	15.4	200.9	17.0	202.5	-32.6	3.62	2.87	26
23	852.3	566.2	48.8	615.0	237.3	17.8	0	17.8	191.2	17.4	190.8	-46.4	3.41	2.73	25
24	488.7	132.7	12.7	145.4	343.3	-0.8	0	-0.8	311.4	30.6	342.8	- 0.4	6.13	0.89	588
25	485.7	122.9	12.0	134.9	350.8	-0.6	0	-0.6	287.8	24.3	312.7	-38.1	5.60	0.98	473
26	475.0	153.6	10.8	164.4	310.6	0.1	0	0.1	299.7	17.1	316.7	+ 6.1	5.67	0.76	648
27	477.7	133.6	10.2	143.8	333.9	0.2	0	0.2	250.4	16.5	266.7	-67.2	4.77	0.77	522

TABLE B-1. CONTINUED

Part VI. - Reactor Filtrate Data for Incremental Addition and Withdrawal of Reagent.

	Lower Kittanning							Illinois No. 5						
Minutes From Start	Solution Removed (g)	S as Sulfate (%)	S as Sulfate (g)	Fe in Solution (%)	Fe in Solution (g)	Fe^{+2} in Solution (%)	Fe^{+2} in Solution (g)	Solution Removed (g)	S as Sulfate (%)	S as Sulfate (g)	Fe in Solution (%)	Fe in Solution (g)	Fe^{+2} in Solution (%)	Fe^{+2} in Solution (g)
EXPERIMENT NO. 20								EXPERIMENT NO. 24						
15	686	0.2041	1.40	10.877	74.6	2.854	19.6	526	0.0510	0.27	6.836	36.0	5.291	27.8
30	580	0.1852	1.07	10.766	62.4	2.728	15.8	561	0.0506	0.28	6.939	38.9	4.903	27.5
45	687	0.1802	1.24	10.988	75.5	2.655	18.2	538	0.0404	0.22	6.987	37.6	4.357	23.4
60	501	0.1575	0.79	10.953	54.9	2.487	12.5	649	0.0417	0.27	7.043	45.7	4.108	26.7
90	713	0.1596	1.14	11.034	78.7	2.739	19.5	685	0.0477	0.33	6.819	46.7	4.413	30.2
120	685	0.1658	1.14	11.009	75.4	2.613	17.9	704	0.0422	0.30	7.090	49.9	4.605	32.4
180	489	0.1644	0.80	10.731	52.5	2.987	14.6	612	0.0622	0.38	6.710	41.1	5.000	30.6
240	2660	0.1721	4.58	11.177	297.3	3.072	81.7	2102	0.0636	1.34	7.052	148.2	5.360	112.7
	7001		12.16		771.3		199.8	6377		3.38		444.1		311.4
EXPERIMENT NO. 21								EXPERIMENT NO. 25						
15	606	0.2133	1.29	10.641	64.5	3.208	19.4	566	0.0646	0.37	6.853	38.8	5.409	30.6
30	465	0.1935	0.90	10.499	48.8	2.901	13.5	688	0.0510	0.35	6.955	47.9	5.100	35.1
45	701	0.1747	1.22	10.899	76.4	2.767	19.4	709	0.0546	0.39	6.993	49.6	4.279	30.3
60	573	0.1532	0.88	10.723	61.4	2.475	14.2	391	0.0717	0.28	7.134	27.9	4.096	16.0
90	677	0.1610	1.09	10.683	72.3	2.606	17.6	547	0.0702	0.38	6.767	37.0	4.447	24.3
120	534	0.1570	0.84	10.682	57.0	2.543	13.6	484	0.0531	0.26	7.143	34.6	4.595	22.2
180	639	0.1750	1.12	10.848	69.3	3.015	19.3	678	0.0579	0.39	6.710	45.5	4.931	33.4
240	2771	0.1788	4.95	11.199	310.3	3.225	89.4	2414	0.0629	1.52	5.365	129.5	3.966	95.7
	6966		12.30		760.2		206.4	6477		3.94		410.7		287.8
EXPERIMENT NO. 22								EXPERIMENT NO. 26						
15	787	0.1631	1.28	11.220	88.3	2.767	21.8	424	0.0372	0.16	6.907	29.3	5.028	21.3
30	945	0.1473	1.39	10.948	103.5	2.592	24.5	408	0.0280	0.11	6.527	26.6	4.342	17.7
45	702	0.1253	0.88	10.966	77.0	2.536	17.8	538	0.0198	0.11	6.946	37.4	4.282	23.0
60	890	0.1557	1.39	10.855	96.6	2.325	20.7	446	0.0437	0.19	6.941	31.0	4.009	17.9
90	704	0.1512	1.06	11.091	78.1	2.706	19.1	528	0.0409	0.22	6.806	35.9	4.136	21.8
120	673	0.1498	1.01	11.130	74.9	2.738	18.4	648	0.0430	0.28	7.027	45.5	4.338	28.1
180	505	0.1728	0.87	10.978	55.4	3.246	16.4	630	0.0370	0.23	6.716	42.3	4.573	28.8
240	1899	0.1695	3.20	10.820	205.5	3.280	62.3	2943	0.0593	1.75	6.976	205.3	4.792	141.0
	7105		11.09		779.2		200.9	6565		3.05		453.3		299.7
EXPERIMENT NO. 23								EXPERIMENT NO. 27						
15	788	0.1608	1.27	11.016	86.8	2.884	22.7	568	0.0576	0.33	6.942	39.4	5.225	29.7
30	560	0.1586	0.89	10.953	61.3	2.810	15.7	498	0.0307	0.15	6.941	34.6	4.691	23.4
45	537	0.1488	0.80	11.060	59.4	2.618	14.1	506	0.0281	0.14	6.312	31.9	4.267	21.6
60	536	0.1317	0.71	10.949	58.7	2.508	13.4	712	0.0265	0.18	7.085	50.4	4.044	28.7
90	497	0.1382	0.69	11.037	54.9	2.784	13.8	671	0.0375	0.25	7.174	48.1	4.207	28.2
120	551	0.1466	0.81	10.887	60.0	2.745	15.1	574	0.0421	0.24	7.052	40.5	4.276	24.5
180	602	0.1383	0.83	10.879	65.5	2.543	15.3	511	0.0530	0.27	6.790	34.7	4.630	23.7
240	2985	0.1475	4.40	10.414	310.9	2.712	81.0	2564	0.0555	1.42	4.070	104.4	2.750	70.5
	7056		10.39		757.4		191.2	6604		3.00		384.0		250.4

TABLE B-2. PYRITIC SULFUR EXTRACTIONS WITH FERRIC SULFATE - PARAMETRIC INVESTIGATIONS

PART I. - Summary of Experimental Conditions

Exp No.	EXPERIMENTAL PARAMETERS											
	Type of Coal	Top Size	Molarities and Reagents Used[a]	Reaction Time (Hours)	Reaction Temp. (°C)	Filtration Time (Minutes)	Washing No. of Washes	Washing Water Temp (°C)	Sulfur Recovery Toluene Reflux Time (Minutes)	Sulfur Recovery Toluene Reflux Temp. (°C)	Coal Drying[b] Temp. (°C)	Coal Drying[b] Time (Hours)
A. LOWER KITTANNING COAL - CONTINUOUS PYRITE EXTRACTIONS WITH PURE FERRIC SULFATE												
28	Lower Kittanning	-14 mesh	1.0M $Fe_2(SO_4)_3$[c]	4	100	10	4	95	60	85	137	6
29	Lower Kittanning	-14 mesh	0.5M $Fe_2(SO_4)_3$[c]	4	99	15	6	95	60	85	135	6
30	Lower Kittanning	-1/4 inch	0.5M $Fe_2(SO_4)_3$	4	101	NA	4	95	60	87	100	18
31	Lower Kittanning	-1/4 inch	0.5M $Fe_2(SO_4)_3$	4	100	30	4	95	60	85	100	18
32	Lower[d] Kittanning	-1/4 inch	0.5M $Fe_2(SO_4)_3$	4	100	15	4	98	60	85	100	8
B. ILLINOIS NO. 5 COAL - CONTINUOUS PYRITE EXTRACTIONS WITH PURE FERRIC SULFATE												
33	Illinois No. 5	-1/4 inch	0.5M $Fe_2(SO_4)_3$	8[e]	101	15	8	95	60	86	100	18
34	Illinois No. 5	-1/4 inch	0.5M $Fe_2(SO_4)_3$	8[e]	102	15	8	95	60	86	100	18
35	Illinois No. 5	-1/4 inch	0.5M $Fe_2(SO_4)_3$	4	100	15	4	80	60	83	105	18
36	Illinois[f] No. 5	-1/4 inch	0.5M $Fe_2(SO_4)_3$	4	100	15	4	80	60	86	105	18
37	Illinois No. 5	-1/4 inch	0.25M $Fe_2(SO_4)_3$	4	97	22	4	90	60	81	105	18
38	Illinois[g] No. 5	-1/4 inch	0.25M $Fe_2(SO_4)_3$	4	101	15	4	80	60	86	105	18
C. EXTRACTIONS WITH COMMERCIAL FERRIC SULFATE (FERRI-FLOC)[h]												
39	Illinois No. 5	-1/4 inch	0.5M $Fe_2(SO_4)_3$	8	101	20	4	96	60	85	105	18
D. TRACE-ELEMENT ANALYSIS SAMPLE GENERATION EXPERIMENTS. MULTI-BATCH PYRITE EXTRACTIONS WITH PURE FERRIC SULFATE.												
40	Lower Kittanning	-14 mesh	0.25M $Fe_2(SO_4)_3$	12	101	15	4	100	60	83	105	18
41	Illinois No. 5	-14 mesh	0.25M $Fe_2(SO_4)_3$	8	100	15	4	100	60	87	100	2

[a]Exact Fe^{+3} and sulfate concentrations are given in the "analytical data" table (Part III). [b]Vacuum drying. [c]H_2SO_4 was added to the reagent solution to furnish 0.10H^+. [d]Second extraction of combined processed coals of experiments 30 and 31. [e]Two-stage extractions. Samples were extracted for four hours, filtered, washed and returned to the reactor for an additional four hour extraction prior to complete processing. [f]Second 4-hour extraction of sample processed during experiment no. 35. [g]Second 4-hour extraction of processed sample no. 37. [h]FerriFloc is composed of approximately 5% insolubles (principally silicates), 90% ferric sulfate and 5% ferrous sulfate and chloride.

TABLE B-2. CONTINUED

PART II. - Process Mass Balance.

Exp. No.	WEIGHTS IN GRAMS															
	Coal in Dry	Processed Coal Dry	Toluene Distillation Residue	Solids Out-In	Reagents In	Water In	Toluene In	Total Liquid Charge	Liquid Out: Reactor Filtrate	Liquid Out: Combined Wash[b]	Liquid Out: Last Wash	Liquid Out: Toluene Distillate	Drier Traps	Total Liquid Out	Liquid Out-In	Net Process Losses
A. LOWER KITTANNING COAL - CONTINUOUS PYRITE EXTRACTION WITH PURE FERRIC SULFATE																
28	1033.8	994.0	3.3	-36.5	4,095.8	3876.8	2794.0	10,766.6	3,759.6	3035.6	908.1	2702.8	207.8	10,613.9	-152.7	-189.2
29	534.1	509.3	4.8	-20.0	6,939.9	5717.0	1363.0	14,019.9	6,729.8	2870.0	2795.8	1293.4	98.0	13,787.0	-232.9	-252.9
30	577.0	557.2	3.4	-16.4	9,148.5	3743.2	1261.7	14,153.4	8,963.3	2842.8	915.6	1216.3	54.0	13,992.0	-161.4	-177.8
31	573.0	551.2	5.8	-16.0	8,828.7	3677.4	1268.1	13,774.2	8,707.0	2772.5	888.3	1203.0	77.6	13,648.4	-125.8	-141.8
32	809.0	795.0	3.0	-11.0	8,511.8	3777.5	2612.0	14,901.3	8,224.0	2862.8	947.9	2470.1	187.0	14,691.8	-209.5	-220.5
B. ILLINOIS NO.5 COAL - CONTINUOUS PYRITE EXTRACTIONS WITH PURE FERRIC SULFATE																
33	483.0	480.8	2.2	0	26,508.0	7928.0	1489.0	35,925.0	26,092.6	5937.1	1929.2	1400.9	124.8	35,484.6	-440.4	-440.4
34	486.0	475.9	1.6	- 8.5	25,880.0	7826.6	1613.0	35,319.6	25,429.2	6091.6	1853.6	1525.0	146.9	35,046.3	-273.3	-281.8
35	454.0	450.3	2.3	- 1.4	13,111.0	4050.3	1288.4	18,449.7	12,840.9	3086.1	1014.0	1198.2	131.3	18,270.5	-179.2	-180.6
36	444.7	454.6	1.2	+11.1	12,550.0	3831.7	1328.8	17,710.5	12,280.6	2917.4	969.5	1222.0	134.8	17,524.3	-186.2	-175.1
37	459.0	451.6	2.0	- 5.4	12,400.0	4082.8	1359.9	17,842.7	12,148.9	3066.1	999.2	1270.6	128.6	17,613.4	-229.3	-234.7
38	442.8	458.2	0.8	+16.2	12,137.0	3916.3	1350.1	17,403.4	11,984.3	2918.1	967.4	1250.9	129.0	17,249.7	-153.7	-137.5
C. EXTRACTIONS WITH COMMERCIAL FERRIC SULFATE (FERRI-FLOC)[h]																
39	462.0	481.0	1.7	+20.7	20,835.0	4064.0	1388.6	26,287.6	20,349.8	3083.1	992.0	1300.9	116.5	25,842.3	-445.3	-424.6
D. TRACE-ELEMENT ANALYSIS SAMPLE GENERATION EXPERIMENTS. MULTI-BATCH PYRITE EXTRACTIONS WITH PURE FERRIC SULFATE																
40	479.0	435.0	4.4	-39.6	22,841.0	3991.8	1410.0	28,242.8	22,329.0	2843.0	983.3	1357.2	18.9	27,531.4	-711.4	-751.0
41	324.6	310.0	3.1	-11.5	14,399.0	4007.1	1225.1	19,631.2	14,140.0	2868.9	993.2	1181.7	54.7	19,238.5	-392.7	-404.2

TABLE B-2. CONTINUED

PART III - Analytical Data for Sulfur and Ion Balances.

Exp. No.	ANALYTICAL DATA, WEIGHT PERCENT[1] (ON DRY BASIS FOR SOLIDS)																				
	Processed Coal						Sulfur as Sulfate In			Sulfur In Toluene Residue	Total Iron In				Fe^{+2}		REAGENT FEED WEIGHT PERCENT			
	Heat Content (BTU/Lb)	Ash	Total Sulfur	Sulfur Forms: Pyritic	Sulfate	Organic	Reactor Filtrate	Combined Wash	Last Wash		Fe in Coal	Fe in Reactor Filtrate	Fe in Combined Wash	Fe in Last Wash	Reactor Filtrate	Combined Wash	Total Iron	Fe^{+3}	Fe^{+2}	Sulfate as Sulfur
A. LOWER KITTANNING COAL - CONTINUOUS PYRITE EXTRACTIONS WITH PURE FERRIC SULFATE																				
28	12,995	15.85	2.71	1.97	0.12	0.62		0.765	0.004	67.7	1.815		0.844	0.002		0.376	9.00	9.00	0	8.50
29	12,718	17.54	2.58	1.91	0.08	0.59		0.223	0.001	81.7	1.846		0.210	0.000		0.062	4.36	4.36	0	4.12
30	12,820	16.98	2.81	2.28	0.03	0.52		0.177	0.002	85.4	2.042		0.236	0.001		0.036	4.83	4.83	0	4.51
31	12,636	17.79	3.44	2.70	0.04	0.70		0.186	0.002	79.6	2.504		0.210	0.001		0.039	4.83	4.83	0	4.51
32	12,916	16.47	2.25	1.74	0.07	0.44		0.359	0.003	77.5	1.581		0.385	0.001		0.071	4.62	4.62	0	4.27
B. ILLINOIS NO. 5 COAL - CONTINUOUS PYRITE EXTRACTIONS WITH PURE FERRIC SULFATE																				
33	12,676	8.48	3.26	0.63	0.46	2.01		0.228	0.036	33.0	0.937		0.232	0.022		0.035	5.04	5.04	0	4.47
34	12,616	8.70	3.33	0.89	0.51	1.93		0.341	0.034	35.9	0.986		0.354	0.027		0.056	5.04	5.04	0	4.47
35								NA	0.031	27.2	NA		0.241	0.022		0.046	5.01	5.01	0	4.38
36	12,738	8.67	3.28	0.85	0.44	1.99		NA	NA	22.6	0.937		0.284	0.019		0.040	4.91	4.91	0	4.45
37								NA	0.017	28.8	NA		0.094	0.010		0.027	2.56	2.56	0	2.26
38	12,711	9.43	3.36	1.16	0.44	1.76*		NA	NA	27.1	1.343		0.067	0.014		0.021	2.81	2.81	0	2.42
C. EXTRACTIONS WITH COMMERCIAL FERRIC SULFATE (FERRI-FLOC)																				
39	12,016	11.12	3.91	1.50	0.04	2.37		NA	NA	30.9	2.644		0.250	0.030		0.020	5.02	4.64	0.38	4.36
D. TRACE-ELEMENT ANALYSIS SAMPLE GENERATION EXPERIMENTS. MULTI-BATCH PYRITE EXTRACTIONS WITH PURE FERRIC SULFATE																				
40	13,320	13.92	1.66	0.95	0.17	0.54		NA	NA	85.6	1.266		0.052	0.002		0.012	2.83	2.83	0	2.58
41	12,511	9.66	2.82	0.67	0.32	1.83		NA	NA	22.1	0.727		0.052	0.005		0.014	2.84	2.84	0	2.65
UNTREATED COALS (11 Sample Averages)																				
Illinois No. 5	12,700 ± 73	11.34 ±0.31	3.53 ±0.12	1.56 ±0.12	0.07 ±0.02	1.96 ±0.17					1.53 (3 sample avg)									
Lower Kittanning	12,319 ± 109	19.72 ±0.60	4.22 ±0.17	3.59 ±0.17	0.06 ±0.03	0.67 ±0.12					3.15 ± 0.10 (3 sample avg)									

See PART VI for filtrate composition at various reaction stages

See PART VI for filtrate composition at various reaction stages

See PART VI for filtrate composition at various reaction stages

[1] Except heat content.

TABLE B-2. CONTINUED

PART IV. - Sulfur Balance and Sulfur Removal Estimates.

Exp. No.	Sulfur In: From Coal	Sulfur In: From Reagents	Sulfur In: Total In	SULFUR BALANCE, GRAMS Sulfur Out: In Processed Coal	In Reactor Filtrate	In Combined Wash	In Last Wash	In Toluene Residue	Sulfur Out-In[j]	Pyrite In	Estimated Pyrite Removal From[k] Δ Total Sulfur In Coal: Grams	%	Δ Sulfur Forms In Coal: Grams	%
A. LOWER KITTANNING COAL - CONTINUOUS PYRITE EXTRACTIONS WITH PURE FERRIC SULFATE														
28	43.63	348.1	391.8	26.94	318.1	23.22	0.04	2.23	-21.3	37.11	-16.69	45.0	-17.53	47.2
29	22.54	285.9	308.5	13.14	286.9	6.40	0.03	3.92	+1.9	19.17	- 9.40	49.0	- 9.45	49.3
30	24.35	412.6	436.9	15.66	401.2	5.03	0.02	2.90	-12.2	20.71	- 8.69	42.0	- 8.12	39.2
31	24.18	398.2	422.4	18.96	385.0	5.16	0.02	4.62	- 8.6	20.57	- 5.22	25.4	- 5.69	27.6
32	25.27	363.5	388.8	17.89	356.2	10.28	0.03	2.33	- 2.1	20.05	- 7.38	36.8	- 6.22	31.0
	48.53			24.51						41.28	-24.02	58.2	-22.33	54.1
B. ILLINOIS NO. 5 COAL - CONTINUOUS PYRITE EXTRACTIONS WITH PURE FERRIC SULFATE														
33	17.05	1184.9	1202.0	15.77	1122.5	13.54	0.69	0.73	-48.7	7.53	- 1.28	17.0	- 3.64	48.3
34	17.16	1156.8	1174.0	15.85	1117.9	20.77	0.63	0.57	-18.3	7.58	- 1.31	17.3	- 3.35	44.1
35	16.03	574.3	590.3	NA	NA	NA	0.31	0.63	---	7.08				
36	NA	558.5	---	14.91	NA	NA	NA	0.27	---	NA	- 1.12[m]	15.8[m]	- 3.22	45.4[m]
37	16.20	280.2	296.4	NA	NA	NA	0.17	0.58	---	7.16				
38	NA	293.7	---	15.40	NA	NA	NA	0.22	---	NA	- 0.80[m]	11.2[m]	- 1.84[m]	25.8[m]
C. EXTRACTIONS WITH COMMERCIAL FERRIC SULFATE (FERRI-FLOC)														
39	16.31	908.4	924.7	18.81	NA	NA	NA	0.53	---	7.21	+ 2.5[n]	(34.7)[n]	+ 0.05[n]	0.0
D. TRACE ELEMENT ANALYSIS SAMPLE GENERATION EXPERIMENTS. MULTI-BATCH PYRITE EXTRACTIONS WITH PURE FERRIC SULFATE														
40	20.21	589.3	609.5	7.22	618.3	NA	NA	3.77	---	17.20	-12.99	75.6	-13.06	76.0
41	11.46	381.6	393.1	8.74	NA	NA	NA	0.69	---	5.06	-2.72	53.6	-2.99	59.0

[j]The amount of sulfur input (as sulfate) is too large in comparison to the sulfur removed from the processed coal; thus, the observed sulfur imbalance (out-in) is due to normal uncertainty in analysis and not to missing sulfur. Subsequent to Experiment No. 34 sulfur analysis of extracts was discontinued except for spot checks on last wash.

[k]Two methods of computing sulfur removal are indicated.

[l]The processed coal from Experiments 30 and 31 served as starting coal for Experiment 32. This row of data indicate pyrite removal during double processing (8 hours).

[m]Double extraction pyritic sulfur removal (8 hours total). The low sulfur removals computed from total sulfur analyses are due to residual sulfate on processed coal (inefficient washing). [n]Sulfur increase!!

TABLE B-2. CONTINUED

PART V. - Iron Mass Balance Data

Exp. No.	TOTAL IRON BALANCE, GRAMS								
	Fe In			Fe Out					Δ Fe Out-In
	From Coal	From Reagents	Total In	In Reactor Filtrate	In Combined Wash	In Last Wash	In Processed Coal	Total Out	
A.	LOWER KITTANNING COAL - CONTINUOUS PYRITE EXTRACTIONS WITH PURE FERRIC SULFATE								
28	32.6	368.6	401.2	358.1	25.6	<0.1	18.1	401.8	+0.6
29	16.8	302.6	319.4	309.4	6.0	<0.1	9.4	324.9	+5.5
30	18.2	441.9	460.0	438.1	6.7	<0.1	11.4	456.2	-3.9
31	18.0	426.4	444.5	425.4	5.8	<0.1	13.8	445.0	+0.5
32	18.4	393.2	411.6	397.2	11.0	<0.1	12.6	420.8	+9.2
B.	ILLINOIS NO. 5 COAL - CONTINUOUS PYRITE EXTRACTIONS WITH PURE FERRIC SULFATE								
33	7.4	1336.0	1343.4	1288.9	13.8	0.4	4.5	1307.6	-35.7
34	7.4	1304.4	1311.8	1278.6	21.6	0.5	4.7	1305.4	-6.4
35 & 36	6.9	1273.1	1280.0	1269.6	15.7	0.4	4.3	1290.0	+10.0
37 & 38	7.0	659.7	666.7	658.2	4.8	0.2	6.2	669.4	+2.7
C.	EXTRACTIONS WITH COMMERCIAL FERRIC SULFATE (FERRI-FLOC)								
39	7.1	1045.9	1053.0	1047.4	7.7	0.3	12.7	1068.1	+15.1
D.	TRACE ELEMENT ANALYSIS SAMPLE GENERATION EXPERIMENTS. MULTI-BATCH EXTRACTIONS WITH PURE $Fe_2(SO_4)_3$								
40	15.1	646.4	661.5	662.7	1.5	<0.1	5.5	669.7	+8.3
41	5.0	408.9	413.9	407.2	1.5	<0.1	2.3	411.0	-2.9

Exp. No.	FERRIC AND FERROUS ION BALANCE, GRAMS										
	Fe^{+3} In	Fe^{+3} Out			Fe^{+3} Used In-Out	Fe^{+2} In		Fe^{+2} Out			Fe^{+2} Produced Out-In	Unaccounted Fe^{+3}
	(Reagents)	Reactor Filtrate	Combined Wash	Total Out		Δ Fe Coal	Reagents	Total In	Reactor Filtrate	Wash Filtrate		
A.	LOWER KITTANNING COAL - CONTINUOUS PYRITE EXTRACTIONS WITH PURE FERRIC SULFATE											
29	368.6	206.0	14.2	220.2	148.4	14.5	0	14.5	152.1	11.4	149.0	+0.6
29	302.6	221.2	4.2	225.4	77.2	7.4	0	7.4	88.3	1.8	82.6	+5.4
30	441.9	369.1	5.7	374.8	67.0	6.8	0	6.8	68.9	1.0	63.2	-3.8
31	426.4	350.3	4.7	355.1	71.4	4.2	0	4.2	75.1	1.1	71.9	+0.5
32	393.2	335.7	9.0	344.7	48.5	5.8	0	5.8	61.5	2.0	57.7	+9.2
B.	ILLINOIS NO.5 COAL - CONTINUOUS PYRITE EXTRACTIONS WITH PURE FERRIC SULFATE											
33	1336.0	1184.8	11.7	1196.5	139.5	2.9	0	2.9	104.2	2.5	103.8	-35.7
34	1304.4	1176.1	18.2	1194.2	110.1	2.7	0	2.7	102.6	3.9	103.7	-6.4
35 & 36	1273.1	1160.6	13.1	1173.7	99.4	2.7	0	2.7	109.0	2.6	108.9	+9.5
37 & 38	658.5	566.5	3.4	569.9	88.6	0.8	0	0.8	91.7	1.4	92.3	+3.7
C.	EXTRACTIONS WITH COMMERCIAL FERRIC SULFATE (FERRI-FLOC)											
39	966.7	888.4	7.1	895.5	71.3	-5.6	79.2	73.5	159.0	0.9	86.4	+15.1
D.	TRACE ELEMENT ANALYSIS SAMPLE GENERATION EXPERIMENTS. MULTI-BATCH PYRITE EXTRACTION WITH PURE FERRIC SULFATE											
40	646.4	530.1	1.1	531.2	115.2	9.6	0	9.6	132.7	0.4	123.5	+8.3
41	408.9	304.8	1.1	305.9	103.0	2.7	0	2.7	102.4	0.5	100.1	-2.9

TABLE B-2. CONTINUED

PART VI - Spent Reagent Composition as a Function of Time.

Reaction Time Interval (Minutes)	Weight of Withdrawn Solution (grams)	Av. Composition of Withdrawn Solution During Indicated Reaction Time Interval: Sulfate as S (w/o)	Sulfate as S (Grams)	Total Iron (w/o)	Total Iron (Grams)	Ferrous Ion (w/o)	Ferrous Ion (Grams)
A. LOWER KITTANNING COAL							
EXPERIMENT NO. 28							
0-240	401.6	8.694	34.28	9.473	37.04	2.738	11.30
240[9]	3358.0	6.451	263.76	9.537	320.25	3.202	141.10
	3759.6		118.78		358.09		152.10
EXPERIMENT NO. 29							
0-240	3201.8	4.129	132.17	4.560	146.03	1.355	43.39
240[9]	3528.0	4.387	154.77	4.933	163.17	1.272	44.09
	6729.8		286.94		309.43		86.69
EXPERIMENT NO. 30							
0-150	3779.0	4.408	166.55	4.934	186.46	0.810	30.63
150-240	1374.0	4.326	59.44	4.902	67.35	0.770	10.58
240[9]	3769.4	4.647	175.16	4.896	184.53	0.736	27.74
	8922.4		401.16		438.34		68.95
	40.9[F]	0.000		0.000		0.000	
	8963.3						
EXPERIMENT NO. 31							
0-150	3563.0	4.465	159.10	4.442	158.28	0.647	23.04
150-240	1177.0	4.543	53.47	4.934	58.07	0.868	10.22
240[9]	3908.3	4.395	171.77	4.993	195.13	0.832	32.52
	8648.3		384.34		411.48		65.78
	59.7[F]	0.000		0.000		0.000	
	8707.0						
EXPERIMENT NO. 32							
0-30	746.0	4.223	31.50	4.712	35.15	0.527	3.93
30-60	679.0	4.232	28.74	4.851	32.94	0.718	4.88
60-90	634.0	4.44	28.15	4.932	30.63	0.704	4.46
90-120	630.0	4.514	28.46	4.943	31.14	0.745	4.70
120-180	725.0	4.603	33.36	5.031	36.47	0.947	6.87
180-240	982.0	4.475	39.47	4.890	33.04	0.890	7.06
240[9]	3924.0	4.234	166.51	4.792	187.93	0.766	30.09
	8274.0		356.19		397.31		63.87
EXPERIMENT NO. 40							
120[5]	3700	2.820	104.34	3.074	113.74	1.564	57.87
240[5]	1747	2.771	103.83	3.376	112.34	1.880	32.97
360[5]	3691	2.733	100.90	2.984	110.10	0.529	19.53
480[5]	8642	2.728	99.15	2.936	108.93	0.277	10.09
600[5]	3745	2.742	104.56	2.894	108.36	0.162	6.92
720[5]	3604	2.769	105.33	2.915	110.89	0.142	5.40
	22,309		618.29		662.74		132.69

Reaction Time Interval (Minutes)	Weight of Withdrawn Solution (grams)	Av. Composition of Withdrawn Solution During Indicated Reaction Time Interval: Sulfate as S (w/o)	Sulfate as S (Grams)	Total Iron (w/o)	Total Iron (Grams)	Ferrous Ion (w/o)	Ferrous Ion (Grams)
B. ILLINOIS NO. 5 COAL							
EXPERIMENT NO. 33							
1st Extraction (4 hours)							
0-30	1431	3.300	47.22	5.332	76.30	0.441	6.37
30-60	921	3.404	31.35	5.117	47.13	0.509	4.67
60-90	830	3.300	27.39	5.309	44.07	0.582	6.59
90-120	994	3.393	33.73	5.068	50.36	0.525	5.22
120-180	1313	3.300	43.33	5.952	78.14	0.924	12.14
180-240	2092	3.184	66.62	5.000	104.60	0.494	10.34
240[9]	3966.5	3.000	122.53	4.988	197.93	0.539	21.39
	12,379.5		394.33		598.73		88.44
2nd Extraction (4 hours)							
0-30	1572	1.447	63.44	4.839	76.14	0.130	2.04
30-60	1069	1.370	44.00	5.044	80.99	0.274	4.41
60-90	1063	1.374	43.79	5.092	80.94	0.220	3.71
90-120	1029	1.405	45.37	5.048	81.73	0.206	3.14
120-180	1610	1.414	64.61	5.109	123.13	0.414	6.00
180-240	2449	1.469	106.35	5.063	124.04	0.313	7.73
240[9]	4116	1.381	174.47	5.093	209.70	0.306	13.36
	14,033		1.3[F]		1,000		37.21
	14,033.1		1,000		1,000		1,000
EXPERIMENT NO. 34							
1st Extraction (4 hours)							
0-30	1765	3.481	60.13	5.164	91.14	0.423	7.47
30-60	1262	3.370	42.52	5.165	65.19	0.434	5.48
60-90	1192	3.310	39.46	5.302	63.20	0.515	6.14
90-120	1244	3.314	41.23	5.102	63.48	0.512	6.37
120-180	2295	3.309	75.95	5.357	122.96	0.577	13.25
180-240	2145	3.433	73.64	5.309	113.91	0.509	10.65
240[9]	3751.6	3.398	127.48	5.098	191.27	0.427	16.32
	12,654.6		460.41		715.15		65.08
2nd Extraction (4 hours)							
0-30	1269	1.431	57.15	4.920	62.44	0.141	1.84
30-60	1204	1.324	52.50	4.929	60.34	0.238	2.93
60-90	1176	1.330	54.23	5.106	64.12	0.269	3.35
90-120	1149	1.352	54.85	5.063	64.79	0.297	3.52
120-180	1861	1.369	94.23	5.064	94.23	0.327	6.34
180-240	2149	1.394	90.36	5.117	109.96	0.360	6.88
240[9]	3630.2	1.444	161.33	5.149	186.42	0.360	13.07
	13,525.3		642.35		817.29		37.47
	42.2[F]	0.000		0.000		0.000	
	13,567.5						

Reaction Time Interval (Minutes)	Weight of Withdrawn Solution (grams)	Av. Composition of Withdrawn Solution During Indicated Reaction Time Interval: Total Iron (w/o)	Total Iron (Grams)	Ferrous Ion (w/o)	Ferrous Ion (Grams)
EXPERIMENT NO. 35					
0-30	1314	5.187	68.16	0.328	4.31
30-60	1206	5.156	62.16	0.523	6.31
60-90	1146	5.161	59.12	0.554	6.35
90-120	959	5.166	49.53	0.541	5.19
120-180	1761	5.166	90.93	0.557	9.92
180-240	2627	5.230	85.09	0.501	8.16
240[9]	4736.1	5.113	485.22	0.471	22.33
	17,714.1		849.61		63.47
	43.3[F]	0.000		0.000	
	17,757.4				
EXPERIMENT NO. 36					
0-30	1237	5.008	61.95	0.290	3.59
30-60	1338	4.861	64.80	0.341	4.46
60-90	999	4.920	49.15	0.360	3.60
90-120	1018	4.917	51.15	0.402	4.18
120-180	1748	4.960	86.59	0.408	7.29
180-240	2145	5.055	108.43	0.408	8.75
240[9]	3723.7	4.946	184.17	0.362	13.48
	12,214.7		606.52		45.53
	85.3[F]	0.000		0.000	
	12,300.0				
EXPERIMENT NO. 37					
0-30	1181	2.673	27.23	0.469	4.87
30-60	931	2.623	24.42	0.441	4.29
60-90	1154	2.[illegible]	30.22	0.490	5.63
90-120	741	2.[illegible]	20.63	0.359	3.63
120-180	1746	2.599	38.60	0.481	8.33
180-240	2703	2.649	59.38	0.361	7.95
240[9]	4039.1	2.631	110.74	0.407	17.13
	12,511.1		319.28		51.83
	33.3[F]	0.000		0.000	
	12,544.4				

Reaction Time Interval (Minutes)	Weight of Withdrawn Solution (grams)	Av. Composition of Withdrawn Solution During Indicated Reaction Time Interval: Total Iron (w/o)	Total Iron (Grams)	Ferrous Ion (w/o)	Ferrous Ion (Grams)
EXPERIMENT NO. 38					
0-30	1336	2.854	38.19	0.268	3.59
30-60	972	2.820	27.41	0.307	2.98
60-90	1112	2.823	31.39	0.341	3.79
90-120	819	2.823	23.12	0.341	2.79
120-180	2516	2.829	59.07	0.357	7.20
180-240	2029	2.930	59.45	0.363	7.37
240[9]	3611.4	2.803	101.23	0.336	12.13
	11,397.4		339.86		39.85
	16.7[F]	0.000		0.000	
	11,414				
EXPERIMENT NO. 39					
0-30	1243	5.551	69.00	0.782	9.72
30-60	925	5.172	47.84	0.866	8.01
60-90	847	5.116	43.33	0.922	7.81
90-120	939	5.188	48.72	0.927	8.70
120-180	2101	5.222	109.71	0.910	19.12
180-240	1931	5.205	100.51	0.838	16.18
240-300	1968	5.116	100.68	0.765	15.06
300-360	2178	5.133	106.66	0.788	16.37
360-420	2143	5.200	111.44	0.771	16.52
420-480	1833	4.983	90.61	0.670	12.28
480[9]	4141.9	5.042	208.81	0.674	29.26
	20,349.9		1047.41		169.03
EXPERIMENT NO. 41					
120[5]	3713	2.900	107.68	1.179	43.66
240[5]	3652	2.874	107.83	0.650	24.39
360[5]	3737	2.875	107.44	0.530	19.87
480[6]	293	2.867	84.23	0.494	14.51
	13,140		407.19		102.37

[9] Filtrate after completion of extraction

[F] Water distilled in traps during reagent exchange.

[5] Filtrate after completion of each batch extraction of the multi-stage extraction experiment.

TABLE B-3. EXPERIMENTAL CONDITIONS FOR EXPERIMENTS 42 THROUGH 64

Exp. No.	
42	Illinois No.5, -1/4 inch coal Commercial ferric sulfate leach solution (Ferri-Floc) 5.1% Fe, 8% as Fe^{+2} Continuous addition and withdrawal of solution Reflux temperature (102°C)
43	Lower Kittannning, -1/4 inch coal Commercial ferric sulfate leach solution (Ferri-Floc) 5.1% Fe, 8% as Fe^{+2} Continuous addition and withdrawal of solution Reflux temperature (102°C)
44	Lower Kittanning, -1/4 inch coal Ferric sulfate leach solution 4.8% Fe, no Fe^{+2} Continuous addition and withdrawal of solution Reflux temperature (102°C)
45	Lower Kittanning, -14 mesh coal Ferric sulfate leach solution 4.8% Fe, no Fe^{+2} Continuous addition and withdrawal of solution Reflux temperature (102°C)
46	Lower Kittanning, -200 mesh coal Ferric sulfate leach solution 4.7% Fe, no Fe^{+2} Continuous addition and withdrawal of solution Reflux temperature (102°C)
47	Lower Kittanning, -100 mesh coal Ferric sulfate leach solution 5.6% Fe, 44% as Fe^{+2} Single batch, filtered samples Reflux temperature (102°C)
48	Lower Kittanning, -100 mesh coal Ferric sulfate leach solution 4.8% Fe, 14% as Fe^{+2} Single batch, filtered samples Reflux temperature (102°C)
49	Lower Kittanning, -100 mesh coal Ferric sulfate leach solution Initial reactor charge 5.1% iron, 52% Fe^{+2} Feed 20 to 80 minutes 4.9% iron, 40% Fe^{+2} Feed 80 to 140 minutes 4.6% iron, 30% Fe^{+2} Feed 140 to 200 minutes 4.6% iron, 22% Fe^{+2} Feed 200 to 410 minutes 4.7% iron, 11% Fe^{+2} Feed 423 to 750 minutes 4.9% iron, 11% Fe^{+2} Continuous addition and withdrawal of solution Reflux temperature (102°C)
50	Lower Kittanning, -100 mesh coal Ferric sulfate leach solution 4.6% Fe, no Fe^{+2} Continuous addition and withdrawal of solution Reflux temperature (102°C)
51	Lower Kittanning, -100 mesh coal Ferric sulfate leach solution 4.8% Fe, no Fe^{+2} Continuous addition and withdrawal of solution Average reaction temperature - 85°C
52	Lower Kittanning, -100 mesh coal Ferric sulfate leach solution 4.7% Fe, no Fe^{+2} Continuous addition and withdrawal of solution Average reaction temperature - 70°C
53	Lower Kittanning, -100 mesh coal Ferric sulfate leach solution Batch 1 (0 to 62 min) 4.9% iron, 51% Fe^{+2} Batch 2 (63 to 146 min) 5.0% iron, 42% Fe^{+2} Batch 3 (147 to 227 min) 4.9% iron, 30% Fe^{+2} Batch 4 (228 to 308 min) 5.0% iron, 20% Fe^{+2} Batch 5 (309 to 393 min) 4.8% iron, 10% Fe^{+2} Batch 6 (394 to 464 min) same Batch 7 (465 to 545 min) same Batch 8 (546 to 616 min) same Batch 9 (617 to 697 min) 4.8% iron, 9% Fe^{+2} Batch 10 (698 to 768 min) same Batch 11 (769 to 909 min) same Solution added at start, withdrawn at end of each batch Batches 1 through 10, 1 hour at reflux (102°C); remaining time 85° to 102° during warm-up Batch 11, 2 hours at reflux (102°C); remainder at 85° to 102° during warm-up
54	Lower Kittanning, -100 mesh coal Ferric sulfate leach solution 3.8% Fe, no Fe^{+2} Continuous addition and withdrawal for 6 hours Batch mode last 6 hours Reflux temperature (102°C)

TABLE B-3. CONTINUED

Exp. No.	
55	Lower Kittanning, -100 mesh coal Ferric sulfate leach solution 5.0% Fe, no Fe^{+2} Continuous addition and withdrawal for 6 hours 4 times rate, first hour 2 times rate, second hour Normal rate, third through sixth hour Batch mode, last six hours Reflux temperature (102°C)
56	Lower Kittanning, -100 mesh coal Ferric sulfate leach solution 6.7% Fe, no Fe^{+2} Continuous addition and withdrawal for 6 hours 4 times rate, first hour 2 times rate, second hour Normal rate, third through sixth hour Batch mode, last six hours Reflux temperature (102°C)
57	Lower Kittanning, -100 mesh coal Ferric sulfate leach solution 7.9% Fe, no Fe^{+2} Continuous addition and withdrawal for 6 hours 4 times rate, first hour 2 times rate, second hour Normal rate, third through sixth hour Batch mode, last six hours Reflux temperature (102°C)
58	Lower Kittanning, -100 mesh coal Ferric sulfate leach solution 10.8% Fe, no Fe^{+2} Continuous addition and withdrawal for 6 hours Batch mode last 6 hours Reflux temperature (102°C)
59	Lower Kittanning, -100 mesh coal Ferric sulfate leach solution 8.5% Fe, 39.8% as Fe^{+2} (room temperature saturated with Fe^{+2}) Continuous addition and withdrawal for 6 hours Batch mode last 6 hours Reflux temperature (102°C)
60	Lower Kittanning, -100 mesh coal Ferric sulfate leach solution 5.2% Fe, no Fe^{+2} 5 times quantity of leach solution Batch mode for 6 hours Reflux temperature (95-102°C)
61	Lower Kittanning, -1/4 inch +10 mesh coal Ferric sulfate leach solution Circulated under 150 psi N_2 pressure 5.1% Fe, no Fe^{+2} Batch mode for 4 hours Temperature 120°C
62	Lower Kittanning, -1/4 inch +10 mesh coal Ferric sulfate leach solution Circulated under 150 psi N_2 pressure 5.0% Fe, no Fe^{+2} Batch mode for 4 hours Temperature 140°C
63	Lower Kittanning, -100 mesh coal Ferric sulfate leach solution Slurry circulated under 150 psi N_2 pressure 4.9% Fe,no Fe^{+2} Batch mode for 4 hours Temperature 130°C
64	Lower Kittanning, -100 mesh coal Ferric sulfate leach solution Slurry circulated under 150 psi O_2 pressure 5.1% Fe, no Fe^{+2} Batch mode with regeneration for 2 hours Temperature 130°C

TABLE B-4. PYRITIC SULFUR EXTRACTIONS WITH COMMERCIAL FERRIC SULFATE

SUMMARY OF REACTION DATA FOR SO4/S= 1.500 ILLINOIS NO.5, -1/4 INCH (FERRI-FLOC). EXP.NO.42 5.1% Fe, 8% as Fe^{+2}

MIN FROM START	FE+2/FE WT. RATIO	COAL WT. FREE OF S(ELEM)	PYRITE REMOVED PCT OF INIT	CUMULATIVE RATE PCT/HR
30	.1379	413.99	25.69	51.37
60	.1491	411.67	35.59	35.59
90	.1530	409.73	43.89	29.26
120	.1540	407.81	52.10	26.05
180	.1460	405.12	63.60	21.20
240	.1321	403.80	69.23	17.31
FROM FINAL COAL ANALYSIS			42.42	

CALCULATED COAL ANALYSES STEP-BY-STEP

TOTAL S WT-PCT	PYR. S WT-PCT	ORG. S WT-PCT	SO4 S WT-PCT	ASH WT-PCT	HT CONTENT BTU/LB
3.236	1.176	1.988	.071	10.378	12826
3.096	1.025	2.000	.071	9.973	12889
2.978	.897	2.009	.072	9.629	12943
2.860	.770	2.019	.072	9.286	12997
2.693	.589	2.032	.073	8.800	13073
2.611	.499	2.039	.073	8.559	13110
3.570	.920	1.950	.700	9.690	12605

SUMMARY OF REACTION DATA FOR SO4/S= 1.500 LOWER KITTANNING, -1/4 INCH (FERRI-FLOC). EXP.NO.43 5.1% Fe, 8% as Fe^{+2}

MIN FROM START	FE+2/FE WT. RATIO	COAL WT. FREE OF S(ELEM)	PYRITE REMOVED PCT OF INIT	CUMULATIVE RATE PCT/HR
30	.1750	575.73	12.76	25.52
60	.1881	574.17	17.43	17.43
90	.1929	573.09	20.66	13.77
120	.1929	572.17	23.43	11.72
180	.1869	570.94	27.10	9.03
240	.1850	569.37	31.80	7.95
FROM FINAL COAL ANALYSIS			36.74	

CALCULATED COAL ANALYSES STEP-BY-STEP

TOTAL S WT-PCT	PYR. S WT-PCT	ORG. S WT-PCT	SO4 S WT-PCT	ASH WT-PCT	HT CONTENT BTU/LB
3.891	3.155	.675	.060	19.585	12357
3.732	2.994	.677	.061	19.473	12381
3.622	2.883	.678	.061	19.394	12398
3.526	2.786	.679	.061	19.327	12413
3.400	2.658	.681	.061	19.237	12432
3.238	2.494	.683	.061	19.122	12456
3.090	2.320	.450	.320	19.000	12384

TABLE B-5. PARTICLE SIZE EFFECT ON PYRITIC SULFUR REMOVAL RATES - CONTINUOUS REAGENT EXCHANGE

SUMMARY OF REACTION DATA FOR SO4/S= 1.500 LOWER KITTANNING, -1/4 INCH. EXP.NO.44 4.8% Fe, no Fe^{+2}.

MIN FROM START	FE+2/FE WT. RATIO	COAL WT. FREE OF S(ELEM)	PYRITE REMOVED PCT OF INIT	CUMULATIVE RATE PCT/HR	CALCULATED COAL ANALYSES STEP-BY-STEP TOTAL S WT-PCT	PYR. S WT-PCT	ORG. S WT-PCT	SO4 S WT-PCT	ASH WT-PCT	HT CONTENT BTU/LB
15	.1740	1055.11	11.54	46.15	3.939	3.203	.676	.061	19.477	12372
30	.1990	1052.91	14.40	28.81	3.843	3.105	.677	.061	19.373	12392
45	.2090	1051.28	16.52	22.03	3.772	3.033	.678	.061	19.296	12407
60	.2154	1049.79	18.45	18.45	3.707	2.967	.679	.061	19.226	12421
75	.2229	1048.48	20.15	16.12	3.650	2.909	.680	.061	19.164	12433
90	.2300	1047.24	21.76	14.51	3.595	2.854	.681	.061	19.105	12444
105	.2358	1046.11	23.22	13.27	3.546	2.803	.681	.061	19.051	12455
120	.2421	1044.97	24.71	12.36	3.495	2.752	.682	.061	18.996	12465
135	.2490	1043.83	26.18	11.64	3.445	2.701	.683	.061	18.942	12476
150	.2510	1042.94	27.35	10.94	3.406	2.661	.684	.061	18.899	12484
165	.2510	1041.65	29.02	10.55	3.348	2.603	.684	.061	18.837	12496
180	.2440	1040.63	30.35	10.12	3.303	2.557	.685	.061	18.788	12506
195	.2371	1039.71	31.54	9.71	3.262	2.515	.686	.061	18.743	12514
210	.2321	1038.79	32.73	9.35	3.221	2.474	.686	.061	18.699	12523
225	.2271	1037.96	33.82	9.02	3.184	2.436	.687	.062	18.659	12531
240	.2229	1037.08	34.95	8.74	3.145	2.396	.687	.062	18.616	12539
255	.2200	1036.16	36.14	8.50	3.104	2.354	.688	.062	18.572	12548
270	.2171	1035.31	37.26	8.28	3.065	2.315	.689	.062	18.530	12556
285	.2140	1034.50	38.30	8.06	3.029	2.278	.689	.062	18.491	12563
300	.2110	1033.72	39.32	7.86	2.994	2.242	.690	.062	18.453	12571
315	.2090	1032.75	40.58	7.73	2.950	2.196	.690	.062	18.405	12580
330	.2071	1032.10	41.42	7.53	2.921	2.168	.691	.062	18.373	12586
345	.2040	1031.51	42.18	7.34	2.894	2.141	.691	.062	18.344	12592
360	.2021	1030.88	43.00	7.17	2.865	2.112	.692	.062	18.313	12598
FROM FINAL COAL ANALYSIS			43.62		3.000	2.090	.690	.220	18.290	12126

TABLE B-5. Continued

SUMMARY OF REACTION DATA FOR SO4/S= 1.500 LOWER KITTANNING, -14 MESH. EXP.NO.45 4.8% Fe, no Fe^{+2}

MIN FROM START	FE+2/FE WT. RATIO	COAL WT. FREE OF S(ELEM)	PYRITE REMOVED PCT OF INIT	CUMULATIVE RATE PCT/HR	CALCULATED COAL ANALYSES STEP-BY-STEP TOTAL S WT-PCT	PYR. S WT-PCT	ORG. S WT-PCT	SO4 S WT-PCT	ASH WT-PCT	HT CONTENT BTU/LB
15	.2459	1000.79	16.80	67.21	3.770	3.029	.680	.061	19.136	12432
30	.2951	996.41	21.99	43.98	3.596	2.853	.683	.061	18.898	12476
45	.3320	992.65	26.44	35.25	3.447	2.700	.685	.061	18.694	12514
60	.3559	990.09	29.46	29.46	3.344	2.596	.687	.062	18.553	12540
75	.3659	987.66	32.33	25.87	3.247	2.497	.689	.062	18.419	12565
90	.3718	985.33	35.10	23.40	3.152	2.400	.690	.062	18.290	12589
105	.3759	983.33	37.46	21.40	3.071	2.318	.692	.062	18.179	12610
120	.3790	981.47	39.66	19.83	2.995	2.240	.693	.062	18.074	12629
135	.3790	979.70	41.75	18.56	2.923	2.166	.694	.062	17.975	12648
150	.3769	978.09	43.66	17.46	2.857	2.099	.695	.062	17.885	12665
165	.3751	976.51	45.53	16.56	2.791	2.033	.696	.062	17.795	12681
180	.3710	975.17	47.11	15.70	2.736	1.976	.697	.062	17.720	12695
195	.3651	973.74	48.80	15.01	2.677	1.916	.698	.063	17.639	12710
210	.3569	971.90	50.98	14.56	2.600	1.838	.700	.063	17.534	12730
225	.3459	970.67	52.43	13.98	2.549	1.786	.701	.063	17.463	12743
240	.3331	969.84	53.42	13.35	2.514	1.750	.701	.063	17.415	12752
255	.3210	968.94	54.48	12.82	2.476	1.712	.702	.063	17.364	12762
270	.3090	967.87	55.75	12.39	2.432	1.666	.703	.063	17.302	12773
285	.2969	966.94	56.85	11.97	2.392	1.626	.703	.063	17.249	12783
300	.2859	966.25	57.67	11.53	2.363	1.596	.704	.063	17.209	12790
315	.2751	965.59	58.44	11.13	2.336	1.568	.704	.063	17.171	12797
330	.2641	964.96	59.19	10.76	2.309	1.541	.705	.063	17.134	12804
345	.2569	964.10	60.21	10.47	2.272	1.504	.705	.063	17.084	12814
360	.2520	962.92	61.60	10.27	2.223	1.453	.706	.063	17.016	12826
FROM FINAL COAL ANALYSIS			65.77		2.200	1.300	.760	.140	16.810	12836

TABLE B-5. Continued

SUMMARY OF REACTION DATA FOR SO4/S= 1.500 LOWER KITTANNING, -200 MESH. EXP.NO.46 4.7% Fe, no Fe^{+2}

MIN FROM START	FE+2/FE WT. RATIO	COAL WT. FREE OF S(ELEM)	PYRITE REMOVED PCT OF INIT	CUMULATIVE RATE PCT/HR	CALCULATED COAL ANALYSES STEP-BY-STEP TOTAL S WT-PCT	PYR. S WT-PCT	ORG. S WT-PCT	SO4 S WT-PCT	ASH WT-PCT	HT CONTENT BTU/LB
10	.1549	755.93	12.69	76.14	3.696	3.160	.675	.060	19.530	12366
25	.2320	749.26	21.02	50.45	3.613	2.873	.679	.061	19.290	12415
40	.3626	740.28	34.80	52.21	3.140	2.393	.685	.061	18.888	12497
55	.3572	738.38	33.97	37.06	3.169	2.423	.685	.061	18.912	12492
70	.3224	733.24	39.36	33.73	2.981	2.233	.687	.062	18.753	12524
85	.3320	729.28	44.49	31.40	2.862	2.050	.689	.062	18.601	12556
100	.3050	725.14	45.86	27.51	2.754	2.002	.690	.062	18.560	12564
115	.2789	721.70	47.04	24.54	2.712	1.960	.691	.062	18.525	12571
130	.2404	718.93	47.40	21.88	2.699	1.947	.691	.062	18.514	12573
145	.2291	715.32	49.36	20.43	2.630	1.876	.692	.062	18.455	12585
160	.2108	711.43	50.84	19.07	2.578	1.823	.692	.062	18.410	12594
175	.2026	707.14	52.98	18.16	2.502	1.747	.693	.062	18.346	12608
190	.1903	702.63	55.61	17.56	2.408	1.652	.694	.062	18.267	12624
205	.1615	698.90	56.56	16.55	2.374	1.617	.695	.062	18.238	12630
220	.1473	695.36	57.33	15.63	2.347	1.590	.695	.062	18.215	12634
235	.1375	691.53	58.53	14.94	2.304	1.546	.696	.062	18.178	12642
250	.1305	687.50	60.34	14.48	2.239	1.480	.697	.062	18.123	12653
265	.1219	683.73	61.67	13.96	2.191	1.432	.697	.062	18.082	12661
280	.1133	680.07	62.82	13.46	2.150	1.390	.698	.062	18.047	12669
295	.1060	676.21	64.53	13.13	2.088	1.327	.698	.063	17.995	12679
310	.0985	672.56	65.80	12.74	2.043	1.281	.699	.063	17.956	12687
325	.0853	669.22	66.20	12.22	2.028	1.267	.699	.063	17.944	12690
340	.0767	665.62	66.96	11.82	2.001	1.239	.700	.063	17.921	12695
355	.0681	662.12	67.94	11.48	1.965	1.202	.700	.063	17.890	12701
370	.0683	658.62	69.01	11.19	1.926	1.163	.701	.063	17.858	12707
371	.0683	658.62	69.01	11.16	1.926	1.163	.701	.063	17.858	12707
381	.0857	643.71	70.43	11.09	1.875	1.111	.701	.063	17.814	12716
391	.0944	641.68	71.14	10.92	1.849	1.085	.702	.063	17.792	12721
406	.0999	637.76	72.85	10.77	1.787	1.022	.702	.063	17.739	12732
421	.0874	635.10	72.94	10.39	1.784	1.019	.702	.063	17.736	12732
436	.0834	631.67	73.77	10.15	1.753	.988	.703	.063	17.710	12738
451	.0768	628.44	74.39	9.90	1.741	.965	.703	.063	17.691	12741
466	.0640	625.54	74.37	9.58	1.732	.965	.703	.063	17.692	12741
481	.0676	621.85	75.53	9.46	1.679	.913	.704	.063	17.648	12750
496	.0650	618.44	76.58	9.26	1.651	.884	.704	.063	17.623	12755
511	.0582	615.38	76.93	9.03	1.638	.870	.704	.063	17.612	12758
526	.0544	611.60	77.51	8.84	1.617	.849	.705	.063	17.594	12761

TABLE B-5. Continued

Exp.No.46 Cont'd.

541	.0524	608.31	78.15	8.67	1.593	.825	.705	.063	17.574	12765
556	.0496	605.04	78.70	8.49	1.573	.805	.705	.063	17.557	12769
571	.0461	601.83	79.24	8.33	1.553	.785	.705	.063	17.540	12772
586	.0444	598.54	79.80	8.17	1.532	.764	.706	.063	17.523	12776
601	.0407	595.37	80.17	8.00	1.519	.750	.706	.063	17.511	12778
616	.0377	592.21	80.54	7.84	1.505	.736	.706	.063	17.500	12781
631	.0359	589.09	80.95	7.70	1.490	.721	.706	.063	17.487	12783
646	.0339	586.03	81.27	7.55	1.478	.709	.706	.063	17.477	12785
661	.0326	583.02	81.55	7.40	1.468	.698	.706	.063	17.468	12787
676	.0315	579.88	81.90	7.27	1.455	.685	.707	.063	17.457	12789
691	.0312	576.75	82.28	7.14	1.441	.671	.707	.063	17.445	12792
706	.0322	573.52	82.74	7.03	1.424	.654	.707	.063	17.431	12795
721	.0343	570.23	83.49	6.95	1.397	.626	.707	.063	17.408	12799
736	.0328	567.14	83.78	6.83	1.386	.615	.707	.063	17.398	12801
751	.0297	563.99	83.93	6.71	1.380	.609	.708	.063	17.394	12802
FROM FINAL COAL ANALYSIS			89.75		1.600	.390	.920	.290	17.210	12253

TABLE B-6. FERRIC ION TO TOTAL IRON RATIO EFFECT ON PYRITIC SULFUR REMOVAL RATE

SUMMARY OF REACTION DATA FOR SO4/S= 1.500 LOWER KITTANNING, -100 MESH. EXP.NO.47 5.6% Fe, 44% as Fe^{+2}

MIN FROM START	FE+2/FE WT. RATIO	COAL WT. FREE OF S(ELEM)	PYRITE REMOVED PCT OF INIT	CUMULATIVE RATE PCT/HR
10	.4475	537.69	.67	4.00
20	.4667	536.43	3.40	10.19
35	.5142	533.33	10.09	17.29
50	.5311	532.23	12.47	14.96
65	.5602	530.37	16.51	15.24
80	.5737	529.50	18.37	13.78
95	.6045	527.55	22.59	14.27
110	.6088	527.28	23.18	12.65
125	.6206	526.54	24.79	11.90
140	.6323	525.81	26.36	11.30
170	.6518	524.61	28.96	10.22
200	.6649	523.81	30.68	9.20
230	.6773	523.06	32.30	8.43
240	.6809	522.85	32.76	8.19
FROM FINAL COAL ANALYSIS			42.57	

CALCULATED COAL ANALYSES STEP-BY-STEP

TOTAL S WT-PCT	PYR. S WT-PCT	ORG. S WT-PCT	SO4 S WT-PCT	ASH WT-PCT	HT CONTENT BTU/LB
4.299	3.568	.670	.060	19.859	12298
4.210	3.478	.672	.060	19.732	12321
3.992	3.256	.676	.061	19.418	12379
3.914	3.176	.677	.061	19.305	12400
3.781	3.041	.680	.061	19.113	12435
3.719	2.977	.681	.061	19.024	12452
3.578	2.834	.683	.061	18.821	12489
3.559	2.814	.684	.061	18.793	12494
3.505	2.759	.685	.061	18.715	12509
3.452	2.705	.686	.061	18.639	12523
3.364	2.616	.687	.062	18.512	12546
3.306	2.556	.688	.062	18.428	12562
3.251	2.500	.689	.062	18.349	12576
3.235	2.484	.689	.062	18.326	12580
3.070	2.140	.780	.150	17.840	12707

SUMMARY OF REACTION DATA FOR SO4/S= 1.500 LOWER KITTANNING, -100 MESH. EXP.NO.48 4.8% Fe, 14% as Fe^{+2}

MIN FROM START	FE+2/FE WT. RATIO	COAL WT. FREE OF S(ELEM)	PYRITE REMOVED PCT OF INIT	CUMULATIVE RATE PCT/HR
10	.1934	527.02	4.94	29.62
20	.2771	523.73	13.15	39.44
35	.3575	520.57	21.03	36.04
50	.4080	518.59	25.96	31.15
65	.4540	516.80	30.42	28.08
80	.4811	515.76	33.03	24.77
95	.5065	514.79	35.44	22.38
110	.5225	514.18	36.96	20.16
125	.5561	512.92	40.11	19.25
140	.5632	512.66	40.76	17.47
170	.5876	511.76	43.00	15.18
200	.6017	511.25	44.28	13.28
230	.6104	510.93	45.06	11.75
240	.6186	510.64	45.78	11.45
FROM FINAL COAL ANALYSIS			52.94	

CALCULATED COAL ANALYSES STEP-BY-STEP

TOTAL S WT-PCT	PYR. S WT-PCT	ORG. S WT-PCT	SO4 S WT-PCT	ASH WT-PCT	HT CONTENT BTU/LB
4.158	3.426	.673	.060	19.700	12328
3.887	3.149	.677	.061	19.382	12389
3.623	2.881	.681	.061	19.073	12448
3.456	2.711	.683	.061	18.877	12485
3.304	2.557	.686	.061	18.699	12519
3.215	2.466	.687	.062	18.594	12539
3.132	2.382	.688	.062	18.497	12558
3.079	2.328	.689	.062	18.435	12570
2.970	2.218	.691	.062	18.308	12594
2.948	2.194	.691	.062	18.281	12599
2.870	2.115	.693	.062	18.190	12617
2.825	2.070	.693	.062	18.137	12627
2.798	2.042	.694	.062	18.105	12633
2.773	2.016	.694	.062	18.076	12638
2.800	1.760	.900	.140	17.780	12710

TABLE B-6. Continued

SUMMARY OF REACTION DATA FOR SO4/S= 1.500 LOWER KITTANNING, -100 MESH. EXP.NO.49 COUNTER CURRENT LEACH

MIN FROM START	FE+2/FE WT. RATIO	COAL WT. FREE OF S(ELEM)	PYRITE REMOVED PCT OF INIT	CUMULATIVE RATE PCT/HR	CALCULATED COAL ANALYSES STEP-BY-STEP TOTAL S WT-PCT	PYR. S WT-PCT	ORG. S WT-PCT	SO4 S WT-PCT	ASH WT-PCT	HT CONTENT BTU/LB
10	.5185	536.78	.16	.97	4.315	3.585	.670	.060	19.884	12293
20	.5253	535.30	1.04	3.13	4.286	3.555	.671	.060	19.853	12299
35	.5046	534.15	2.29	3.93	4.245	3.514	.671	.060	19.807	12308
50	.5237	531.14	6.20	7.44	4.116	3.383	.673	.060	19.666	12335
65	.5403	526.63	9.41	8.68	4.010	3.275	.675	.060	19.550	12358
80	.5561	522.49	13.09	9.82	3.887	3.150	.676	.061	19.415	12384
95	.5492	518.40	16.52	10.44	3.772	3.033	.678	.061	19.290	12408
110	.5450	514.51	18.50	10.09	3.706	2.966	.679	.061	19.217	12422
125	.5556	509.64	21.49	10.32	3.605	2.863	.681	.061	19.106	12444
140	.5539	505.90	23.96	10.27	3.521	2.778	.682	.061	19.014	12461
155	.5528	501.67	27.41	10.61	3.404	2.659	.684	.061	18.886	12486
170	.5332	497.82	29.17	10.30	3.344	2.598	.685	.061	18.820	12499
185	.5253	494.47	32.59	10.57	3.226	2.479	.686	.061	18.691	12524
200	.4985	491.51	33.25	9.98	3.204	2.456	.687	.061	18.666	12529
215	.4730	487.76	36.13	10.08	3.105	2.355	.688	.062	18.558	12550
230	.4411	485.07	35.50	9.26	3.126	2.377	.688	.062	18.582	12545
245	.4203	481.46	38.01	9.31	3.040	2.289	.689	.062	18.487	12563
260	.4074	477.01	42.47	9.80	2.885	2.131	.691	.062	18.317	12596
290	.3883	472.36	47.29	9.78	2.716	1.960	.694	.062	18.131	12632
320	.3551	468.86	49.38	9.26	2.642	1.885	.695	.062	18.051	12648
350	.3326	464.76	52.55	9.01	2.530	1.771	.697	.062	17.928	12671
380	.3196	460.82	56.36	8.90	2.395	1.634	.699	.063	17.780	12700
410	.2917	457.79	58.00	8.49	2.337	1.574	.700	.063	17.716	12713
411	.2917	457.79	58.00	8.47	2.337	1.574	.700	.063	17.716	12713
423	.2975	446.14	58.79	8.34	2.308	1.546	.700	.063	17.685	12719
450	.2894	441.75	63.40	8.45	2.143	1.378	.702	.063	17.503	12754
480	.2728	438.39	65.86	8.23	2.054	1.287	.704	.063	17.406	12772
510	.2573	435.06	67.51	7.94	1.995	1.227	.705	.063	17.341	12785
540	.2574	431.34	70.68	7.85	1.879	1.110	.706	.063	17.214	12810
570	.2409	428.73	71.39	7.52	1.853	1.083	.707	.063	17.186	12815
600	.2325	426.13	73.58	7.36	1.774	1.002	.708	.063	17.099	12832
630	.2089	423.50	73.04	6.96	1.793	1.022	.708	.063	17.120	12828
690	.2007	418.89	78.46	6.82	1.595	.820	.711	.064	16.902	12870
750	.1678	415.80	79.16	6.33	1.568	.794	.711	.064	16.874	12875
FROM FINAL COAL ANALYSIS			85.90		1.660	.540	.900	.220	16.600	12736

TABLE B-6. Continued

SUMMARY OF REACTION DATA FOR SO4/S= 1.500 LOWER KITTANNING, -100 MESH. EXP.NO. 50 4.6% Fe, no Fe^{+2}

MIN FROM START	FE+2/FE WT. RATIO	COAL WT. FREE OF S(ELEM)	PYRITE REMOVED PCT OF INIT	CUMULATIVE RATE PCT/HR	CALCULATED COAL ANALYSES STEP-BY-STEP TOTAL S WT-PCT	PYR. S WT-PCT	ORG. S WT-PCT	SO4 S WT-PCT	ASH WT-PCT	HT CONTENT BTU/LB
12	.1315	698.18	11.17	55.86	3.950	3.214	.675	.060	19.516	12366
27	.2554	689.18	24.11	53.58	3.513	2.771	.681	.061	19.076	12452
42	.3069	682.96	31.68	45.26	3.254	2.506	.685	.061	18.814	12504
57	.3441	677.04	37.95	39.95	3.038	2.288	.688	.062	18.596	12547
72	.3581	672.24	43.03	35.66	2.861	2.108	.691	.062	18.417	12582
87	.3650	667.70	47.14	32.51	2.717	1.962	.693	.062	18.272	12610
102	.3319	664.95	47.11	27.71	2.718	1.963	.693	.062	18.273	12610
117	.3076	661.43	48.63	24.94	2.664	1.909	.693	.062	18.219	12621
132	.2912	657.62	50.73	23.06	2.590	1.833	.694	.062	18.144	12635
147	.2684	654.09	52.09	21.26	2.542	1.785	.695	.062	18.096	12645
162	.2560	648.81	55.23	20.46	2.430	1.671	.697	.062	17.983	12667
177	.2344	646.52	56.42	19.12	2.388	1.628	.697	.062	17.940	12675
192	.2169	643.05	57.95	18.11	2.334	1.573	.698	.063	17.885	12686
207	.2020	639.52	59.46	17.23	2.280	1.518	.699	.063	17.831	12697
222	.1908	635.90	61.14	16.52	2.220	1.457	.700	.063	17.770	12709
237	.1798	632.22	62.93	15.93	2.155	1.392	.701	.063	17.705	12722
252	.1668	629.07	63.63	15.15	2.130	1.366	.701	.063	17.680	12727
267	.1626	626.01	65.46	14.71	2.064	1.299	.702	.063	17.613	12740
282	.1524	622.48	66.78	14.21	2.016	1.251	.703	.063	17.565	12749
297	.1511	618.93	69.00	13.94	1.936	1.169	.704	.063	17.484	12765
312	.1277	616.12	68.56	13.19	1.952	1.185	.704	.063	17.500	12762
327	.1252	612.72	70.02	12.85	1.899	1.131	.704	.063	17.446	12773
342	.1197	609.39	71.37	12.52	1.850	1.081	.705	.063	17.397	12782
357	.1095	606.12	72.37	12.16	1.813	1.045	.705	.063	17.360	12790
372	.1021	602.75	73.54	11.86	1.770	1.001	.706	.063	17.317	12798
373	.1021	602.75	73.54	11.83	1.770	1.001	.706	.063	17.317	12798
388	.1066	598.80	73.97	11.59	1.755	.985	.706	.063	17.301	12801
343	.1162	595.47	74.89	11.43	1.721	.951	.707	.063	17.267	12808
403	.1258	592.21	75.82	11.29	1.687	.917	.707	.063	17.233	12815
418	.1137	589.16	76.23	10.94	1.672	.901	.707	.063	17.218	12818
433	.1057	585.90	77.14	10.69	1.638	.867	.708	.063	17.184	12824
448	.0951	582.96	77.70	10.41	1.618	.846	.708	.063	17.163	12828
463	.0900	579.94	78.73	10.20	1.580	.808	.709	.063	17.125	12836
478	.0825	576.73	79.54	9.98	1.550	.777	.709	.064	17.095	12842
493	.0774	573.45	80.44	9.80	1.515	.742	.710	.064	17.059	12849
508	.0731	570.58	81.01	9.57	1.496	.723	.710	.064	17.040	12853
523	.0683	567.61	81.84	9.39	1.465	.691	.710	.064	17.009	12859

TABLE B-6. Continued

538	.0651	554.95	82.47	9.20
553	.0621	551.96	83.17	9.02
568	.0585	548.91	83.81	8.85
583	.0560	546.96	84.59	8.71
598	.0538	542.92	85.24	8.55
613	.0507	540.23	85.76	8.39
628	.0472	537.42	86.13	8.23
643	.0428	534.61	86.38	8.06
658	.0454	531.50	87.46	7.98
673	.0403	528.72	87.57	7.81
688	.0367	525.91	87.90	7.67
703	.0336	522.82	88.19	7.53
718	.0346	519.84	88.90	7.43
733	.0315	517.03	89.13	7.30
748	.0310	513.98	89.60	7.19
763	.0340	510.80	90.43	7.11
FROM FINAL COAL ANALYSIS			91.65	

Exp.No.50 Continued

1.442	.666	.711	.064	16.986	12863
1.419	.644	.711	.064	16.962	12868
1.392	.617	.711	.064	16.935	12873
1.363	.586	.712	.064	16.906	12879
1.339	.563	.712	.064	16.882	12884
1.320	.544	.712	.064	16.862	12887
1.306	.530	.713	.064	16.848	12890
1.297	.520	.713	.064	16.839	12892
1.256	.479	.713	.064	16.798	12900
1.253	.475	.713	.064	16.794	12901
1.240	.463	.714	.064	16.782	12903
1.229	.452	.714	.064	16.771	12905
1.203	.425	.714	.064	16.744	12911
1.194	.416	.714	.064	16.735	12912
1.177	.398	.714	.064	16.718	12916
1.145	.367	.715	.064	16.686	12922
1.430	.320	.860	.250	16.640	12744

TABLE B-7. TEMPERATURE EFFECT AT AMBIENT PRESSURE ON PYRITIC SULFUR REMOVAL RATE

SUMMARY OF REACTION DATA FOR SO4/S= 1.500 LOWER KITTANNING, -100 MESH EXP.NO.51 4.8% Fe, no Fe^{+2}

MIN FROM START	FE+2/FE WT. RATIO	COAL WT. FREE OF S(ELEM)	PYRITE REMOVED PCT OF INIT	CUMULATIVE RATE PCT/HR	CALCULATED COAL ANALYSES STEP-BY-STEP TOTAL S WT-PCT	PYR. S WT-PCT	ORG. S WT-PCT	SO4 S WT-PCT	ASH WT-PCT	HT CONTENT BTU/LB
15	.0827	633.33	8.68	34.70	4.033	3.299	.674	.060	19.598	12349
30	.1470	627.41	16.50	32.99	3.771	3.033	.678	.061	19.331	12402
45	.1884	621.96	23.11	30.81	3.548	2.806	.681	.061	19.103	12446
60	.2157	616.92	28.46	28.46	3.365	2.620	.684	.061	18.917	12483
75	.2289	612.10	33.27	26.62	3.200	2.453	.686	.061	18.749	12516
90	.2361	607.73	37.02	24.68	3.070	2.321	.688	.062	18.617	12542
105	.2332	603.87	39.78	22.73	2.974	2.224	.689	.062	18.519	12561
120	.2317	599.97	42.57	21.29	2.877	2.125	.691	.062	18.420	12581
135	.2353	595.82	45.98	20.44	2.758	2.004	.692	.062	18.299	12604
150	.2299	592.21	48.10	19.24	2.684	1.928	.693	.062	18.223	12619
165	.2268	588.41	50.62	18.41	2.595	1.838	.695	.062	18.132	12637
180	.2173	585.08	52.06	17.35	2.544	1.786	.695	.062	18.080	12647
195	.2056	581.89	53.35	16.42	2.498	1.740	.696	.062	18.034	12656
210	.2083	577.98	56.27	16.08	2.394	1.634	.697	.062	17.928	12677
225	.1853	575.13	56.78	15.14	2.376	1.616	.698	.062	17.909	12681
240	.1912	570.95	59.84	14.96	2.267	1.505	.699	.063	17.798	12703
255	.1772	567.78	60.96	14.34	2.226	1.464	.700	.063	17.757	12711
270	.1592	564.93	60.98	13.55	2.226	1.463	.700	.063	17.756	12711
285	.1506	561.87	62.09	13.07	2.186	1.423	.700	.063	17.716	12719
300	.1434	558.88	63.03	12.61	2.152	1.389	.701	.063	17.682	12725
315	.1359	555.87	63.65	12.16	2.123	1.358	.701	.063	17.651	12731
330	.1268	552.79	64.87	11.79	2.086	1.321	.702	.063	17.614	12739
345	.1274	549.62	66.34	11.54	2.032	1.267	.703	.063	17.560	12749
360	.1349	546.00	68.76	11.46	1.945	1.178	.704	.063	17.470	12767
361	.1349	546.00	68.76	11.43	1.945	1.178	.704	.063	17.470	12767
375	.1383	532.63	70.70	11.31	1.874	1.106	.705	.063	17.399	12781
390	.1118	529.97	70.19	10.80	1.893	1.125	.705	.063	17.418	12777
405	.0985	527.01	70.58	10.46	1.879	1.111	.705	.063	17.403	12780
420	.0940	523.85	71.48	10.21	1.846	1.078	.705	.063	17.370	12787
435	.0937	520.56	72.87	10.05	1.795	1.026	.706	.063	17.318	12797
450	.0949	517.37	74.08	9.88	1.751	.981	.707	.063	17.273	12806
465	.0914	514.32	74.86	9.66	1.723	.952	.707	.063	17.244	12811
480	.0899	511.18	75.90	9.49	1.685	.914	.708	.063	17.205	12819
495	.0896	508.18	77.04	9.34	1.643	.871	.708	.063	17.163	12827
510	.0878	505.25	77.84	9.16	1.612	.840	.709	.063	17.131	12834
525	.0846	502.14	78.82	9.01	1.577	.805	.709	.063	17.096	12840
540	.0805	499.14	79.59	8.84	1.549	.776	.709	.064	17.067	12846

TABLE B-7. Continued

Exp.No.51 Cont'd.

555	.0754	490.15	80.09	8.66	1.530	.757	.710	.064	17.048	12850
570	.0700	493.25	80.53	8.48	1.514	.741	.710	.064	17.032	12853
585	.0689	490.14	81.39	8.35	1.482	.708	.710	.064	16.999	12859
600	.0590	487.37	81.46	8.15	1.480	.706	.710	.064	16.997	12860
615	.0565	484.45	82.09	8.01	1.456	.682	.711	.064	16.973	12865
630	.0537	481.61	82.69	7.88	1.434	.660	.711	.064	16.950	12869
645	.0526	478.64	83.61	7.78	1.400	.625	.712	.064	16.915	12876
660	.0469	476.04	83.59	7.60	1.401	.626	.712	.064	16.916	12876
675	.0456	473.25	84.06	7.47	1.383	.608	.712	.064	16.899	12879
690	.0413	470.56	84.16	7.32	1.380	.604	.712	.064	16.895	12880
705	.0394	467.72	84.62	7.20	1.363	.587	.712	.064	16.877	12883
720	.0395	464.85	85.29	7.11	1.338	.562	.712	.064	16.852	12888
FROM FINAL COAL ANALYSIS			89.03		1.330	.420	.730	.180	16.710	12142

TABLE B-7. Continued

SUMMARY OF REACTION DATA FOR SO4/S= 1.500 LOWER KITTANNING, -100 MESH EXP. NO.52 4.7% Fe, no Fe^{+2}

MIN FROM START	FE+2/FE WT. RATIO	COAL WT. FREE OF S(ELEM)	PYRITE REMOVED PCT OF INIT	CUMULATIVE RATE PCT/HR	CALCULATED COAL ANALYSES STEP-BY-STEP TOTAL S WT-PCT	PYR. S WT-PCT	ORG. S WT-PCT	SO4 S WT-PCT	ASH WT-PCT	HT CONTENT BTU/LB
15	.0687	682.39	6.21	24.86	4.116	3.382	.673	.060	19.663	12336
30	.0990	677.71	10.05	20.10	3.989	3.253	.675	.060	19.522	12363
45	.1141	673.84	12.99	17.32	3.891	3.154	.676	.061	19.413	12384
60	.1491	668.71	17.94	17.94	3.725	2.985	.679	.061	19.228	12420
75	.1611	664.69	20.58	16.47	3.636	2.895	.680	.061	19.130	12439
90	.1664	660.63	23.38	15.59	3.541	2.799	.682	.061	19.024	12459
105	.1567	657.24	24.44	13.97	3.505	2.762	.682	.061	18.984	12467
120	.1554	653.47	26.32	13.16	3.441	2.697	.683	.061	18.913	12480
135	.1600	649.37	28.80	12.80	3.357	2.611	.684	.061	18.819	12499
150	.1467	646.16	29.61	11.84	3.330	2.583	.685	.061	18.789	12504
165	.1533	642.03	32.29	11.74	3.238	2.490	.686	.061	18.687	12524
180	.1375	639.05	32.54	10.85	3.229	2.481	.686	.061	18.677	12526
195	.1448	634.98	35.06	10.79	3.142	2.393	.688	.062	18.581	12545
210	.1344	631.72	35.80	10.23	3.117	2.367	.688	.062	18.552	12550
225	.1295	628.13	37.18	9.91	3.069	2.319	.689	.062	18.499	12560
240	.1295	624.35	39.15	9.79	3.001	2.249	.690	.062	18.423	12575
255	.1256	620.80	40.49	9.53	2.954	2.202	.691	.062	18.371	12585
270	.1162	617.54	41.19	9.15	2.930	2.177	.691	.062	18.344	12590
285	.1129	613.96	42.65	8.98	2.879	2.125	.692	.062	18.288	12601
300	.1067	610.57	43.59	8.72	2.846	2.092	.692	.062	18.251	12608
315	.1044	607.01	44.89	8.55	2.801	2.046	.693	.062	18.201	12618
330	.0986	603.77	45.56	8.28	2.777	2.022	.693	.062	18.175	12623
345	.0971	600.29	46.78	8.14	2.735	1.979	.694	.062	18.127	12632
360	.0947	596.88	47.82	7.97	2.698	1.941	.694	.062	18.087	12640
361	.0947	596.88	47.82	7.95	2.698	1.941	.694	.062	18.087	12640
375	.0938	588.36	48.51	7.76	2.674	1.917	.695	.062	18.060	12645
390	.0904	584.97	49.48	7.61	2.640	1.882	.695	.062	18.022	12652
405	.0895	581.49	50.68	7.51	2.597	1.839	.696	.062	17.975	12661
420	.0871	578.06	51.60	7.37	2.565	1.806	.696	.062	17.939	12668
435	.0855	574.57	52.62	7.26	2.529	1.769	.697	.062	17.898	12676
450	.0874	570.86	54.08	7.21	2.477	1.717	.698	.062	17.841	12687
465	.0846	567.42	54.95	7.08	2.450	1.689	.698	.063	17.810	12693
480	.0817	564.00	55.58	6.95	2.424	1.663	.699	.063	17.782	12699
495	.0799	560.54	56.45	6.84	2.393	1.631	.699	.063	17.747	12705
510	.0767	557.15	57.15	6.72	2.368	1.606	.699	.063	17.719	12711
525	.0750	553.71	57.95	6.62	2.339	1.577	.700	.063	17.688	12717
540	.0708	550.40	58.42	6.49	2.322	1.559	.700	.063	17.669	12720

TABLE B-7. Continued

Exp.No.52 Cont'd.

555	.0734	545.75	59.73	6.40	2.276	1.512	.701	.063	17.617	12730
570	.0759	543.16	60.97	6.42	2.231	1.467	.701	.063	17.567	12740
585	.0752	539.71	61.84	6.34	2.200	1.435	.702	.063	17.533	12747
600	.0690	536.56	61.98	6.20	2.195	1.430	.702	.063	17.527	12748
615	.0738	533.02	63.59	6.20	2.137	1.371	.703	.063	17.463	12760
630	.0672	529.93	63.59	6.06	2.137	1.371	.703	.063	17.463	12760
645	.0650	526.56	64.28	5.98	2.112	1.346	.703	.063	17.435	12765
660	.0599	523.35	64.56	5.87	2.102	1.336	.703	.063	17.424	12768
675	.0612	520.09	65.64	5.83	2.063	1.296	.704	.063	17.381	12776
690	.0546	517.14	65.78	5.72	2.058	1.291	.704	.063	17.375	12777
705	.0606	513.61	67.44	5.74	1.998	1.230	.705	.063	17.308	12790
720	.0625	510.28	68.55	5.71	1.958	1.189	.706	.063	17.263	12799
FROM FINAL COAL ANALYSIS			69.88		1.910	1.140	.660	.110	17.210	12836

TABLE B-8. MULTI-BATCH EXTRACTION OF PYRITIC SULFUR FROM COAL

SUMMARY OF REACTION DATA FOR SO4/S= 1.500 LOWER KITTANNING, -100 MESH EXP.NO.53 COUNTER CURRENT MULTI-BATCH LEACH

MIN FROM START	FE+2/FE WT. RATIO	COAL WT. FREE OF S(ELEM)	PYRITE REMOVED PCT OF INIT	CUMULATIVE RATE PCT/HR	CALCULATED COAL ANALYSES STEP-BY-STEP TOTAL S WT-PCT	PYR. S WT-PCT	ORG. S WT-PCT	SO4 S WT-PCT	ASH WT-PCT	HT CONTENT BTU/LB
15	.5186	657.79	.50	2.01	4.304	3.574	.670	.060	19.864	12297
32	.5534	653.39	4.07	7.63	4.190	3.457	.673	.060	19.674	12331
47	.5700	650.14	5.78	7.38	4.135	3.401	.674	.060	19.583	12347
62	.6135	645.18	10.29	9.96	3.989	3.252	.677	.061	19.341	12391
63	.6135	645.18	10.29	9.80	3.989	3.252	.677	.061	19.341	12391
73	.4243	627.52	9.78	8.04	4.006	3.269	.676	.061	19.369	12386
83	.4434	624.47	11.88	8.59	3.937	3.199	.678	.061	19.256	12407
101	.4867	619.64	16.68	9.91	3.780	3.039	.681	.061	18.996	12454
116	.5157	615.94	19.91	10.30	3.674	2.930	.683	.061	18.819	12485
131	.5402	611.74	22.65	10.37	3.583	2.837	.685	.061	18.669	12513
146	.5574	608.22	24.58	10.10	3.519	2.772	.686	.061	18.562	12532
147	.5574	608.22	24.58	10.03	3.519	2.772	.686	.061	18.562	12532
157	.3239	593.33	25.87	9.89	3.476	2.727	.687	.061	18.491	12545
167	.3502	588.88	28.80	10.35	3.377	2.627	.689	.062	18.328	12574
182	.3863	584.50	32.83	10.82	3.241	2.488	.691	.062	18.102	12615
197	.4122	579.88	35.74	10.88	3.143	2.387	.693	.062	17.938	12645
212	.4394	575.37	38.81	10.98	3.037	2.280	.695	.062	17.764	12676
227	.4511	572.34	40.13	10.61	2.992	2.233	.696	.062	17.689	12690
228	.4511	572.34	40.13	10.56	2.992	2.233	.696	.062	17.689	12690
238	.2135	551.71	40.60	10.24	2.976	2.217	.697	.062	17.662	12694
248	.2345	548.00	43.08	10.42	2.890	2.130	.698	.063	17.521	12720
263	.2703	544.24	47.32	10.79	2.743	1.979	.701	.063	17.277	12764
278	.2845	541.06	49.00	10.58	2.684	1.919	.702	.063	17.179	12782
293	.3017	537.89	51.06	10.46	2.612	1.846	.704	.063	17.060	12803
308	.3192	534.50	53.15	10.35	2.539	1.770	.705	.063	16.938	12825
309	.3192	534.50	53.15	10.32	2.539	1.770	.705	.063	16.938	12825
319	.1023	518.52	52.78	9.93	2.552	1.784	.705	.063	16.959	12821
333	.1203	515.13	54.95	9.90	2.475	1.705	.706	.063	16.832	12844
348	.1393	512.08	57.24	9.87	2.394	1.622	.708	.063	16.697	12869
363	.1561	509.06	59.28	9.80	2.321	1.548	.710	.064	16.577	12890
378	.1670	506.31	60.61	9.62	2.273	1.499	.710	.064	16.498	12905
393	.1814	502.76	62.36	9.52	2.211	1.435	.712	.064	16.394	12924
394	.1814	502.76	62.36	9.50	2.211	1.435	.712	.064	16.394	12924
404	.0995	486.41	62.37	9.26	2.210	1.435	.712	.064	16.393	12924
419	.1113	482.82	63.86	9.15	2.157	1.380	.713	.064	16.304	12940
434	.1212	479.63	65.13	9.00	2.111	1.334	.714	.064	16.229	12953
449	.1304	476.60	66.29	8.86	2.069	1.290	.714	.064	16.159	12966

TABLE B-8. Continued

Exp.No.53 Continued

464	.1368	473.84	67.11	8.68	2.039	1.260	.715	.064	16.110	12975
465	.1368	473.84	67.11	8.66	2.039	1.260	.715	.064	16.110	12975
475	.0912	453.63	66.29	8.37	2.069	1.291	.714	.064	16.159	12966
485	.0966	450.42	67.03	8.29	2.042	1.263	.715	.064	16.115	12974
500	.1035	447.43	67.96	8.16	2.008	1.229	.716	.064	16.059	12984
515	.1085	444.55	68.63	8.00	1.984	1.204	.716	.064	16.018	12991
530	.1125	441.74	69.17	7.83	1.964	1.184	.717	.064	15.986	12997
545	.1193	438.76	70.11	7.72	1.930	1.149	.717	.064	15.929	13007
546	.1193	438.76	70.11	7.70	1.930	1.149	.717	.064	15.929	13007
556	.0954	425.84	70.00	7.55	1.934	1.153	.717	.064	15.936	13006
571	.0973	423.16	70.26	7.38	1.925	1.143	.717	.064	15.920	13009
586	.0995	420.45	70.58	7.23	1.913	1.131	.718	.064	15.901	13013
601	.1070	417.42	71.66	7.15	1.873	1.091	.713	.064	15.835	13025
616	.1084	414.67	71.86	7.00	1.866	1.083	.718	.064	15.823	13027
617	.1084	414.67	71.86	6.99	1.866	1.083	.718	.064	15.823	13027
627	.0916	403.99	72.11	6.90	1.857	1.074	.719	.064	15.808	13029
637	.0913	401.13	72.07	6.79	1.858	1.075	.719	.064	15.810	13029
652	.0942	398.19	72.50	6.67	1.843	1.060	.719	.064	15.784	13034
667	.0963	395.50	72.81	6.55	1.831	1.048	.719	.064	15.765	13037
682	.1110	391.97	74.98	6.60	1.752	.966	.721	.065	15.633	13061
697	.1004	390.31	73.42	6.32	1.809	1.025	.720	.064	15.728	13044
698	.1004	390.31	73.42	.31	1.809	1.025	.720	.064	15.728	13044
708	.0907	373.83	73.59	6.24	1.803	1.019	.720	.064	15.718	13046
723	.0923	370.96	73.86	6.13	1.793	1.009	.720	.064	15.702	13049
738	.0936	368.41	74.07	6.02	1.785	1.000	.720	.064	15.688	13051
753	.0963	365.68	74.51	5.94	1.769	.984	.720	.065	15.662	13056
768	.0949	363.19	74.28	5.80	1.777	.992	.720	.065	15.676	13053
769	.0949	363.19	74.28	5.80	1.777	.992	.720	.065	15.676	13053
779	.0908	346.79	74.53	5.74	1.768	.983	.720	.065	15.661	13056
789	.0913	343.99	74.61	5.67	1.765	.980	.720	.065	15.655	13057
804	.0930	341.12	74.92	5.59	1.754	.969	.721	.065	15.637	13060
819	.0934	338.53	74.99	5.49	1.751	.966	.721	.065	15.632	13061
834	.0945	336.09	75.19	5.41	1.744	.958	.721	.065	15.620	13063
849	.0955	333.45	75.37	5.33	1.737	.952	.721	.065	15.609	13065
864	.0957	331.17	75.39	5.24	1.736	.951	.721	.065	15.608	13066
879	.0969	328.53	75.62	5.16	1.728	.942	.721	.065	15.594	13068
894	.0987	325.86	75.93	5.10	1.716	.930	.721	.065	15.575	13072
909	.0950	323.50	75.27	4.97	1.741	.955	.721	.065	15.615	13064
FROM FINAL COAL ANALYSIS			96.96		1.260	.120	.930	.210	14.260	13258

TABLE B-9. TOTAL IRON CONCENTRATION EFFECT ON PYRITIC SULFUR REMOVAL RATE

SUMMARY OF REACTION DATA FOR SO4/S= 1.500 LOWER KITTANNING, -100 MESH. EXP.NO.54 3.8% Fe, no Fe^{+2}

MIN FROM START	FE+2/FE WT. RATIO	COAL WT. FREE OF S(ELEM)	PYRITE REMOVED PCT OF INIT	CUMULATIVE RATE PCT/HR	CALCULATED COAL ANALYSES STEP-BY-STEP TOTAL S WT-PCT	PYR. S WT-PCT	ORG. S WT-PCT	SO4 S WT-PCT	ASH WT-PCT	HT CONTENT BTU/LB
10	.0537	781.86	3.21	19.27	4.217	3.485	.672	.060	19.722	12322
25	.1295	775.07	8.62	20.69	4.043	3.307	.675	.060	19.437	12374
40	.2165	767.33	15.38	23.06	3.823	3.082	.680	.061	19.076	12439
55	.2606	761.23	19.94	21.75	3.673	2.929	.683	.061	18.830	12484
70	.3082	754.38	25.39	21.76	3.491	2.744	.686	.061	18.533	12538
85	.3275	748.17	29.88	21.09	3.340	2.589	.689	.062	18.286	12582
100	.3676	740.97	35.75	21.45	3.141	2.386	.693	.062	17.960	12641
115	.3630	736.64	37.94	19.79	3.066	2.310	.695	.062	17.837	12663
130	.3648	731.58	40.92	18.89	2.964	2.205	.697	.062	17.669	12694
145	.3409	727.27	42.73	17.68	2.901	2.141	.698	.062	17.567	12712
160	.3166	723.35	44.13	16.55	2.853	2.092	.699	.063	17.488	12727
175	.3051	719.16	45.83	15.71	2.794	2.032	.700	.063	17.392	12744
190	.2844	715.25	47.14	14.89	2.748	1.985	.701	.063	17.317	12758
205	.2752	711.33	48.65	14.24	2.696	1.931	.702	.063	17.230	12773
220	.2639	707.43	50.06	13.65	2.646	1.881	.703	.063	17.150	12788
235	.2551	703.46	51.58	13.17	2.593	1.826	.704	.063	17.062	12804
250	.2463	699.53	53.00	12.72	2.543	1.775	.705	.063	16.980	12819
265	.2389	695.59	54.48	12.34	2.491	1.722	.706	.063	16.895	12834
280	.2332	691.28	56.54	12.12	2.418	1.647	.707	.063	16.775	12856
295	.2662	685.23	61.12	12.43	2.254	1.480	.710	.064	16.508	12904
310	.2222	683.02	60.16	11.64	2.289	1.515	.710	.064	16.564	12894
325	.2181	678.98	61.91	11.43	2.226	1.451	.711	.064	16.461	12912
340	.2289	674.24	64.51	11.38	2.132	1.356	.713	.064	16.308	12940
355	.1745	672.65	62.62	10.58	2.200	1.425	.712	.064	16.419	12920
370	.1656	669.15	63.63	10.32	2.164	1.388	.712	.064	16.360	12931
371	.1656	669.15	63.63	10.29	2.164	1.388	.712	.064	16.360	12931
380	.1763	655.84	64.36	10.16	2.138	1.361	.713	.064	16.317	12939
390	.1888	652.32	65.19	10.03	2.108	1.330	.713	.064	16.268	12947
405	.2015	648.79	66.05	9.78	2.077	1.299	.714	.064	16.217	12957
420	.2159	645.19	67.01	9.57	2.042	1.263	.715	.064	16.160	12967
435	.2271	641.71	67.76	9.35	2.015	1.236	.715	.064	16.115	12975
450	.2327	638.48	68.14	9.09	2.001	1.221	.715	.064	16.093	12979
465	.2416	635.10	68.73	8.87	1.979	1.199	.716	.064	16.058	12985
480	.2501	631.73	69.30	8.66	1.959	1.178	.716	.064	16.024	12992
495	.2604	628.31	69.98	8.48	1.934	1.153	.717	.064	15.983	12999
510	.2540	625.57	69.56	8.18	1.949	1.169	.716	.064	16.008	12994
525	.2654	622.11	70.31	8.04	1.922	1.141	.717	.064	15.963	13002

TABLE B-9. Continued

Exp.No.54 Continued

540	.2725	618.81	70.78	7.86	1.905	1.123	.717	.064	15.935	13008
555	.2764	615.64	71.03	7.68	1.895	1.114	.717	.064	15.920	13010
570	.2805	612.67	71.30	7.51	1.886	1.104	.718	.064	15.904	13013
585	.2845	609.64	71.56	7.34	1.876	1.094	.718	.064	15.889	13016
600	.2892	606.72	71.87	7.19	1.865	1.082	.718	.064	15.870	13019
615	.2924	604.10	72.07	7.03	1.857	1.075	.718	.064	15.858	13022
630	.2984	600.88	72.46	6.90	1.843	1.060	.719	.064	15.834	13026
645	.3024	597.75	72.72	6.76	1.834	1.050	.719	.064	15.819	13029
660	.3059	594.63	72.95	6.63	1.825	1.042	.719	.064	15.805	13031
675	.3099	591.50	73.20	6.51	1.816	1.033	.719	.064	15.790	13034
690	.3120	588.39	73.34	6.38	1.811	1.027	.719	.064	15.782	13035
705	.3144	585.31	73.49	6.25	1.805	1.022	.719	.064	15.773	13037
720	.3184	582.34	73.74	6.15	1.796	1.012	.719	.064	15.757	13040
735	.3204	579.48	73.87	6.03	1.792	1.008	.720	.064	15.750	13041
750	.3217	576.54	73.95	5.92	1.788	1.004	.720	.064	15.745	13042
FROM FINAL COAL ANALYSIS			90.05		1.440	.390	.790	.260	14.760	12937

TABLE B-9. Continued

SUMMARY OF REACTION DATA FOR SO4/S= 1.500 LOWER KITTANNING, -100 MESH, EXP.NO.55 5.0% Fe, no Fe^{+2}

MIN FROM START	FE+2/Fe WT. RATIO	COAL WT. FREE OF S(ELEM)	PYRITE REMOVED PCT OF INIT	CUMULATIVE RATE PCT/HR	CALCULATED COAL ANALYSES STEP-BY-STEP TOTAL S WT-PCT	PYR. S WT-PCT	ORG. S WT-PCT	SO4 S WT-PCT	ASH WT-PCT	HT CONTENT BTU/LB
10	.0600	830.15	4.68	28.08	4.166	3.434	.672	.060	19.720	12325
25	.1700	821.76	18.45	44.29	3.708	2.966	.679	.061	19.214	12423
40	.1950	816.03	27.87	41.80	3.369	2.643	.684	.061	18.863	12490
55	.1810	812.33	33.93	37.02	3.161	2.432	.687	.062	18.653	12535
70	.1460	810.05	37.68	32.29	3.052	2.301	.689	.062	18.491	12562
85	.1590	807.03	42.64	30.10	2.879	2.126	.692	.062	18.301	12599
100	.1610	804.45	46.88	26.13	2.731	1.975	.694	.062	18.137	12631
115	.1500	802.85	49.50	25.82	2.639	1.881	.695	.062	18.035	12650
130	.1340	801.84	51.15	23.61	2.580	1.822	.696	.062	17.971	12663
145	.1480	800.16	53.92	22.31	2.482	1.722	.698	.062	17.863	12684
160	.1550	798.78	56.18	21.07	2.402	1.641	.699	.063	17.774	12701
175	.1600	797.55	58.19	19.95	2.330	1.568	.700	.063	17.695	12716
190	.1640	796.60	59.76	18.87	2.274	1.511	.701	.063	17.633	12728
205	.1644	795.73	61.18	17.91	2.223	1.459	.701	.063	17.577	12739
220	.1620	794.90	62.55	17.06	2.174	1.409	.702	.063	17.523	12749
235	.1550	794.35	63.45	16.20	2.141	1.376	.703	.063	17.487	12756
250	.1510	793.66	64.59	15.50	2.100	1.334	.703	.063	17.442	12765
265	.1460	793.10	65.51	14.83	2.067	1.300	.704	.063	17.405	12772
280	.1410	792.42	66.62	14.28	2.027	1.260	.704	.063	17.361	12781
295	.1330	791.89	67.48	13.73	1.996	1.228	.705	.063	17.326	12787
310	.1230	791.52	68.10	13.18	1.973	1.205	.705	.063	17.302	12792
325	.1100	791.36	68.36	12.62	1.964	1.196	.705	.063	17.291	12794
340	.1010	790.99	68.97	12.17	1.942	1.173	.706	.063	17.267	12799
355	.0970	790.54	69.70	11.78	1.915	1.146	.706	.063	17.237	12804
370	.0960	789.98	70.62	11.45	1.882	1.112	.706	.063	17.201	12812
371	.0960	789.98	70.62	11.42	1.882	1.112	.706	.063	17.201	12812
381	.1165	775.32	72.06	11.35	1.829	1.059	.707	.063	17.143	12823
391	.1219	772.03	72.44	11.12	1.815	1.045	.707	.063	17.127	12826
406	.1367	768.49	73.48	10.86	1.777	1.006	.708	.063	17.085	12834
421	.1493	764.95	74.37	10.60	1.745	.973	.709	.063	17.050	12841
436	.1570	761.65	74.91	10.31	1.725	.953	.709	.063	17.028	12845
451	.1685	758.11	75.71	10.07	1.696	.923	.709	.064	16.995	12851
466	.1725	755.22	76.00	9.78	1.685	.912	.709	.064	16.984	12853
481	.1809	751.92	76.58	9.55	1.664	.891	.710	.064	16.960	12858
496	.1876	748.90	77.05	9.32	1.647	.873	.710	.064	16.941	12862
511	.1944	745.65	77.52	9.10	1.629	.856	.710	.064	16.922	12865
526	.1969	742.65	77.69	8.86	1.623	.849	.710	.064	16.915	12867

TABLE B-9. Continued

Exp.No.55 Continued

541	.2043	739.54	78.20	8.67	1.604	.830	.711	.064	16.894	12871
556	.2092	736.43	78.54	8.48	1.592	.817	.711	.064	16.881	12873
571	.2154	733.30	78.95	8.30	1.576	.802	.711	.064	16.864	12877
586	.2151	730.41	78.94	8.08	1.577	.802	.711	.064	16.864	12877
601	.2218	727.32	79.40	7.93	1.560	.785	.711	.064	16.846	12880
616	.2260	724.26	79.68	7.76	1.550	.774	.711	.064	16.834	12882
631	.2309	721.29	80.01	7.61	1.537	.762	.712	.064	16.821	12885
646	.2304	718.42	79.98	7.43	1.539	.763	.712	.064	16.822	12885
661	.2346	715.49	80.27	7.29	1.528	.753	.712	.064	16.810	12887
676	.2387	712.41	80.54	7.15	1.518	.742	.712	.064	16.799	12889
691	.2451	709.31	80.97	7.03	1.502	.726	.712	.064	16.782	12892
706	.2462	706.34	81.04	6.89	1.500	.724	.712	.064	16.779	12893
721	.2449	703.77	80.95	6.74	1.503	.727	.712	.064	16.782	12892
736	.2520	700.64	81.42	6.64	1.485	.709	.712	.064	16.763	12896
751	.2553	697.74	81.64	6.52	1.477	.701	.713	.064	16.754	12898
FROM FINAL COAL ANALYSIS			91.95		1.500	.310	.950	.240	16.330	13059

TABLE B-9. Continued

SUMMARY OF REACTION DATA FOR SO4/S= 1.500 LOWER KITTANNING, -100 MESH. EXP.NO.56 6.7% Fe, no Fe^{+2}

MIN FROM START	FE+2/FE WT. RATIO	COAL WT. FREE OF S(ELEM)	PYRITE REMOVED PCT OF INIT	CUMULATIVE RATE PCT/HR	CALCULATED COAL ANALYSES STEP-BY-STEP TOTAL S WT-PCT	PYR. S WT-PCT	ORG. S WT-PCT	SO4 S WT-PCT	ASH WT-PCT	HT CONTENT BTU/LB
10	.0300	781.36	3.58	21.48	4.206	3.473	.672	.060	19.700	12326
25	.0800	773.68	13.99	33.57	3.869	3.129	.679	.061	19.139	12426
40	.1230	766.72	23.41	35.12	3.558	2.812	.685	.061	18.622	12521
55	.1450	760.26	32.15	35.08	3.265	2.512	.691	.062	18.134	12609
70	.1590	753.70	41.05	35.18	2.961	2.201	.697	.062	17.628	12700
85	.1420	751.99	43.36	30.60	2.881	2.120	.699	.063	17.496	12724
100	.1330	749.97	46.09	27.66	2.786	2.023	.700	.063	17.338	12753
115	.1250	747.85	48.97	25.55	2.686	1.921	.702	.063	17.171	12783
130	.1200	745.45	52.22	24.10	2.572	1.804	.705	.063	16.981	12817
145	.1190	744.11	54.03	22.36	2.508	1.739	.706	.063	16.875	12836
160	.1220	742.48	56.24	21.09	2.430	1.659	.707	.063	16.744	12860
175	.1290	740.56	58.84	20.17	2.337	1.564	.709	.064	16.591	12888
190	.1330	738.90	61.09	19.29	2.257	1.482	.711	.064	16.457	12912
205	.1320	737.71	62.71	18.35	2.199	1.423	.712	.064	16.360	12929
220	.1280	736.76	63.99	17.45	2.152	1.376	.713	.064	16.283	12943
235	.1240	736.03	64.98	16.59	2.117	1.339	.714	.064	16.224	12954
250	.1190	735.34	65.91	15.82	2.083	1.305	.714	.064	16.168	12964
265	.1130	734.29	67.33	15.24	2.032	1.252	.715	.064	16.082	12979
280	.1080	733.36	68.59	14.70	1.986	1.205	.716	.064	16.006	12993
295	.1030	732.52	69.73	14.18	1.944	1.163	.717	.064	15.937	13006
310	.0980	731.76	70.73	13.69	1.908	1.126	.718	.064	15.876	13017
325	.0940	730.96	71.85	13.26	1.867	1.084	.719	.064	15.808	13029
340	.0900	730.21	72.87	12.86	1.830	1.046	.719	.064	15.746	13040
355	.0860	729.57	73.73	12.46	1.798	1.014	.720	.064	15.693	13050
370	.0840	728.96	74.56	12.09	1.767	.982	.721	.065	15.642	13059
371	.0840	728.96	74.56	12.06	1.767	.982	.721	.065	15.642	13059
381	.1016	719.58	76.50	12.05	1.696	.909	.722	.065	15.523	13080
396	.1049	716.54	76.87	11.65	1.682	.895	.722	.065	15.501	13084
411	.1099	713.22	77.41	11.30	1.662	.875	.723	.065	15.467	13091
426	.1168	709.95	78.18	11.01	1.654	.846	.723	.065	15.420	13099
441	.1230	706.47	78.85	10.73	1.609	.820	.724	.065	15.378	13107
456	.1266	703.19	79.27	10.43	1.593	.804	.724	.065	15.352	13111
471	.1317	700.04	79.80	10.17	1.573	.784	.724	.065	15.319	13117
486	.1345	696.93	80.11	9.89	1.562	.772	.725	.065	15.300	13121
501	.1386	693.79	80.56	9.65	1.545	.755	.725	.065	15.273	13126
516	.1415	690.87	80.87	9.40	1.534	.744	.725	.065	15.254	13129
531	.1445	687.67	81.20	9.17	1.521	.731	.725	.065	15.233	13133

TABLE B-9. Continued

Exp.No.56 Continued

546	.1435	684.82	81.09	8.91	1.525	.735	.725	.065	15.240	13132
561	.1531	681.47	82.12	8.78	1.467	.696	.726	.065	15.176	13143
576	.1566	678.36	82.50	8.59	1.473	.681	.726	.065	15.152	13147
591	.1581	675.27	82.66	8.39	1.467	.675	.727	.065	15.142	13149
606	.1594	672.33	82.79	8.20	1.462	.670	.727	.065	15.134	13151
621	.1639	668.96	83.28	8.05	1.443	.651	.727	.065	15.103	13156
636	.1662	665.96	83.52	7.88	1.435	.642	.727	.065	15.089	13159
651	.1700	662.81	83.92	7.73	1.419	.627	.727	.065	15.063	13163
666	.1720	659.72	84.14	7.58	1.411	.618	.728	.065	15.050	13166
681	.1726	656.61	84.22	7.42	1.408	.615	.728	.065	15.045	13167
696	.1754	653.54	84.49	7.28	1.398	.605	.728	.065	15.028	13170
711	.1759	651.02	84.55	7.13	1.396	.603	.728	.065	15.024	13170
726	.1784	647.89	84.81	7.01	1.386	.593	.728	.065	15.008	13173
741	.1801	644.78	84.99	6.88	1.379	.586	.728	.065	14.997	13175
FROM FINAL COAL ANALYSIS			91.60		1.410	.330	.840	.240	14.580	12742

TABLE B-9. Continued

SUMMARY OF REACTION DATA FOR SO4/S= 1.500 LOWER KITTANNING, -100 MESH. EXP.NO.57 7.9% Fe, no Fe^{+2}

MIN FROM START	FE+2/FE WT. RATIO	COAL WT. FREE OF S(ELEM)	PYRITE REMOVED PCT OF INIT	CUMULATIVE RATE PCT/HR	CALCULATED COAL ANALYSES STEP-BY-STEP TOTAL S WT-PCT	PYR. S WT-PCT	ORG. S WT-PCT	SO4 S WT-PCT	ASH WT-PCT	HT CONTENT BTU/LB
10	.0220	785.06	3.22	19.32	4.215	3.483	.672	.060	19.765	12316
25	.0430	780.48	10.85	26.03	3.963	3.227	.676	.061	19.466	12373
40	.0450	777.76	15.37	23.06	3.813	3.074	.678	.061	19.287	12407
55	.0500	774.67	20.51	22.38	3.641	2.839	.681	.061	19.083	12446
70	.0650	770.99	26.62	22.82	3.434	2.689	.684	.061	18.837	12493
85	.0840	767.83	31.88	22.50	3.255	2.507	.687	.061	18.624	12533
100	.0930	764.38	37.63	22.58	3.057	2.305	.690	.062	18.389	12578
115	.1000	761.26	42.82	22.34	2.877	2.122	.693	.062	18.175	12619
130	.1040	758.67	47.12	21.75	2.726	1.969	.695	.062	17.996	12653
145	.0960	758.17	47.96	19.84	2.697	1.939	.695	.062	17.962	12659
160	.1000	757.22	49.52	18.57	2.642	1.883	.696	.062	17.896	12672
175	.1040	755.63	52.17	17.89	2.549	1.788	.698	.062	17.785	12693
190	.1080	753.62	55.52	17.53	2.430	1.667	.700	.063	17.644	12720
205	.1100	752.46	57.45	16.82	2.361	1.598	.701	.063	17.562	12735
220	.1090	751.27	59.43	16.21	2.290	1.526	.702	.063	17.478	12751
235	.1010	750.60	60.53	15.46	2.251	1.486	.702	.063	17.431	12760
250	.1075	748.44	64.13	15.39	2.122	1.354	.705	.063	17.278	12790
265	.0900	748.91	63.35	14.34	2.150	1.383	.704	.063	17.311	12783
280	.0870	747.95	64.95	13.92	2.092	1.324	.705	.063	17.243	12796
295	.0850	747.18	66.23	13.47	2.046	1.277	.706	.063	17.188	12807
310	.0810	746.55	67.28	13.02	2.008	1.238	.706	.063	17.143	12815
325	.0760	745.78	68.56	12.66	1.962	1.191	.707	.063	17.087	12826
340	.0710	745.47	69.08	12.19	1.943	1.172	.707	.063	17.065	12830
355	.0660	744.81	70.17	11.86	1.903	1.132	.708	.063	17.018	12839
370	.0620	744.36	70.92	11.50	1.876	1.104	.708	.063	16.985	12845
371	.0620	744.36	70.92	11.47	1.876	1.104	.708	.063	16.985	12845
381	.0791	730.46	73.28	11.54	1.789	1.016	.710	.064	16.883	12865
396	.0837	727.06	73.92	11.20	1.766	.992	.710	.064	16.855	12870
411	.0887	723.53	74.61	10.89	1.741	.966	.711	.064	16.825	12876
426	.0947	719.75	75.45	10.63	1.710	.935	.711	.064	16.789	12883
441	.0965	719.30	75.69	10.30	1.701	.926	.711	.064	16.778	12885
456	.1003	712.75	76.22	10.03	1.682	.907	.711	.064	16.755	12889
471	.1060	708.97	76.99	9.81	1.655	.878	.712	.064	16.721	12896
486	.1084	705.61	77.32	9.55	1.641	.865	.712	.064	16.707	12898
501	.1106	702.03	77.62	9.30	1.630	.854	.712	.064	16.694	12901
516	.1266	697.63	79.84	9.28	1.548	.771	.714	.064	16.596	12919
531	.1175	695.07	78.57	8.88	1.595	.819	.713	.064	16.652	12909

TABLE B-9. Continued

Exp.No. 57 Continued

546	.1190	691.77	73.78	8.66	1.587	.811	.713	.064	16.643	12911
561	.1229	688.16	79.31	8.48	1.568	.791	.713	.064	16.620	12915
576	.1228	685.07	79.29	8.26	1.568	.791	.713	.064	16.620	12915
591	.1278	681.38	79.96	8.12	1.544	.766	.714	.064	16.591	12920
606	.1303	678.05	80.30	7.95	1.531	.753	.714	.064	16.576	12923
621	.1342	674.51	80.82	7.81	1.512	.734	.714	.064	16.553	12928
636	.1353	671.25	80.97	7.64	1.507	.728	.714	.064	16.547	12929
651	.1347	667.95	80.89	7.46	1.509	.731	.714	.064	16.550	12928
666	.1368	664.54	81.18	7.31	1.499	.720	.714	.064	16.538	12931
681	.1260	662.05	79.73	7.22	1.552	.775	.713	.064	16.601	12919
696	.1333	658.44	80.71	6.96	1.516	.738	.714	.064	16.558	12927
711	.1418	654.53	81.83	6.91	1.474	.696	.715	.064	16.509	12936
726	.1446	651.13	82.20	6.79	1.461	.682	.715	.064	16.492	12939
741	.1471	647.66	82.52	6.68	1.449	.670	.715	.064	16.478	12942
FROM FINAL COAL ANALYSIS			87.00		1.610	.500	.850	.260	16.280	12887

TABLE B-9. Continued

SUMMARY OF REACTION DATA FOR SO4/S= 1.500 LOWER KITTANNING, -100 MESH. EXP.NO.58 10.8% Fe, no Fe^{+2}

MIN FROM START	FE+2/FE WT. RATIO	COAL WT. FREE OF S(ELEM)	PYRITE REMOVED PCT OF INIT	CUMULATIVE RATE PCT/HR	CALCULATED COAL ANALYSES STEP-BY-STEP TOTAL S WT-PCT	PYR. S WT-PCT	ORG. S WT-PCT	SO4 S WT-PCT	ASH WT-PCT	HT CONTENT BTU/LB
10	.0140	793.93	2.99	17.97	4.223	3.492	.672	.060	19.749	12318
25	.0330	790.60	7.82	18.76	4.067	3.332	.675	.060	19.520	12360
40	.0490	787.52	12.29	18.44	3.920	3.183	.677	.061	19.306	12399
55	.0660	784.15	17.18	18.74	3.759	3.018	.680	.061	19.071	12443
70	.0850	780.09	23.06	19.76	3.563	2.819	.684	.061	18.784	12495
85	.1025	775.79	29.28	20.67	3.354	2.605	.687	.062	18.478	12552
100	.1120	773.01	33.32	19.99	3.217	2.465	.690	.062	18.278	12589
115	.1205	769.58	38.28	19.97	3.047	2.292	.693	.062	18.030	12634
130	.1305	765.89	43.62	20.13	2.862	2.103	.696	.062	17.760	12684
145	.1335	762.28	48.86	20.22	2.680	1.917	.700	.063	17.493	12733
160	.1255	760.57	51.34	19.25	2.592	1.828	.701	.063	17.365	12757
175	.1120	759.60	52.74	18.08	2.543	1.778	.702	.063	17.293	12770
190	.0980	758.67	54.09	17.08	2.495	1.729	.703	.063	17.223	12783
205	.0840	758.75	53.98	15.80	2.499	1.733	.703	.063	17.229	12782
220	.0775	757.80	55.36	15.10	2.450	1.684	.704	.063	17.158	12795
235	.0735	756.73	56.90	14.53	2.395	1.627	.705	.063	17.077	12810
250	.0730	755.57	58.58	14.06	2.335	1.566	.706	.063	16.990	12826
265	.0760	754.23	60.53	13.70	2.266	1.496	.707	.063	16.888	12844
280	.0730	753.24	61.96	13.28	2.215	1.443	.708	.063	16.813	12858
295	.0640	752.25	63.39	12.89	2.163	1.391	.709	.063	16.738	12872
310	.0580	752.23	63.43	12.28	2.162	1.389	.709	.063	16.736	12872
325	.0560	751.44	64.57	11.92	2.121	1.347	.710	.064	16.676	12883
340	.0550	750.33	66.17	11.68	2.063	1.288	.711	.064	16.591	12899
355	.0540	749.73	67.05	11.33	2.031	1.256	.711	.064	16.545	12907
370	.0530	748.98	68.14	11.05	1.992	1.216	.712	.064	16.487	12918
371	.0530	748.98	68.14	11.02	1.992	1.216	.712	.064	16.487	12918
380	.0729	725.49	70.93	11.20	1.890	1.112	.714	.064	16.338	12945
390	.0757	722.20	71.33	10.97	1.875	1.097	.714	.064	16.317	12949
405	.0836	717.01	72.44	10.73	1.835	1.056	.715	.064	16.258	12960
420	.0968	712.16	74.27	10.61	1.768	.987	.716	.064	16.160	12978
435	.0932	708.72	73.78	10.18	1.786	1.006	.716	.064	16.186	12973
450	.0988	704.41	74.55	9.94	1.757	.977	.716	.064	16.145	12981
465	.1027	700.27	75.08	9.69	1.738	.957	.717	.064	16.116	12986
480	.1070	696.10	75.67	9.46	1.716	.935	.717	.064	16.085	12992
495	.1123	691.84	76.40	9.26	1.689	.907	.718	.064	16.045	12999
510	.1139	688.10	76.60	9.01	1.682	.900	.718	.064	16.034	13001
525	.1170	684.05	77.03	8.80	1.666	.884	.718	.064	16.011	13006

TABLE B-9. Continued

Exp.No.58 Continued

540	.1203	679.98	77.46	8.61	1.650	.867	.718	.064	15.988	13010
555	.1237	675.92	77.92	8.42	1.633	.850	.719	.064	15.963	13014
570	.1264	671.89	78.28	8.24	1.620	.837	.719	.064	15.944	13018
585	.1289	667.89	78.61	8.06	1.607	.824	.719	.064	15.926	13021
600	.1330	663.78	79.14	7.91	1.588	.804	.719	.064	15.897	13027
615	.1366	659.70	79.61	7.77	1.570	.786	.720	.064	15.872	13031
630	.1395	655.73	79.98	7.62	1.557	.772	.720	.064	15.852	13035
645	.1377	652.15	79.76	7.42	1.565	.781	.720	.064	15.864	13033
660	.1422	648.08	80.33	7.30	1.544	.759	.720	.064	15.833	13038
675	.1571	643.18	82.22	7.31	1.473	.687	.721	.065	15.730	13057
690	.1466	640.18	80.90	7.03	1.523	.738	.721	.065	15.802	13044
705	.1481	636.31	81.08	6.90	1.516	.731	.721	.065	15.792	13046
720	.1501	632.39	81.33	6.78	1.507	.721	.721	.065	15.778	13048
735	.1529	628.41	81.68	6.67	1.494	.708	.721	.065	15.759	13052
750	.1576	624.31	82.25	6.58	1.472	.686	.721	.065	15.728	13058
FROM FINAL COAL ANALYSIS			86.60		1.750	.520	.830	.400	15.490	12887

TABLE B-9. Continued

SUMMARY OF REACTION DATA FOR SO4/S= 1.500 LOWER KITTANNING, - 100 MESH, EXP.NO.59 8.5% Fe, 39.8% as Fe^{+2}

MIN FROM START	FE+2/FE WT. RATIO	COAL WT. FREE OF S(GRAM)	PYRITE REMOVED PCT OF INIT	CUMULATIVE RATE PCT/HR	CALCULATED COAL ANALYSES STEP-BY-STEP TOTAL S WT-PCT	PYR. S WT-PCT	ORG. S WT-PCT	SO4 S WT-PCT	ASH WT-PCT	HT CONTENT BTU/LB
10	.4020	779.48	.75	4.52	4.296	3.565	.670	.060	19.854	12299
25	.4090	778.46	2.22	5.34	4.249	3.517	.671	.060	19.782	12312
40	.4160	777.37	3.81	5.71	4.197	3.465	.672	.060	19.705	12326
55	.4220	776.24	5.44	5.94	4.145	3.411	.673	.060	19.625	12340
70	.4280	775.05	7.17	6.15	4.098	3.354	.674	.060	19.540	12356
85	.4340	773.77	8.99	6.35	4.029	3.293	.675	.060	19.451	12372
100	.4400	772.45	11.08	6.65	3.961	3.224	.677	.061	19.348	12391
115	.4450	771.99	13.05	6.81	3.896	3.158	.678	.061	19.251	12409
130	.4500	769.61	15.05	6.95	3.831	3.091	.679	.061	19.151	12427
145	.4550	767.79	17.40	7.20	3.753	3.012	.680	.061	19.034	12449
160	.4580	766.61	19.40	7.27	3.687	2.944	.682	.061	18.934	12467
175	.4600	765.41	21.14	7.25	3.629	2.885	.683	.061	18.847	12483
190	.4610	764.23	22.85	7.22	3.572	2.827	.684	.061	18.761	12499
205	.4620	762.96	24.66	7.22	3.511	2.765	.685	.061	18.669	12515
220	.4630	761.86	26.29	7.17	3.457	2.709	.686	.061	18.587	12531
235	.4622	760.89	27.69	7.07	3.409	2.661	.687	.062	18.516	12544
250	.4618	760.06	28.89	6.93	3.369	2.620	.688	.062	18.455	12555
265	.4610	759.28	30.02	6.80	3.331	2.581	.688	.062	18.397	12565
280	.4600	758.54	31.09	6.66	3.294	2.544	.689	.062	18.342	12575
295	.4580	757.77	32.21	6.55	3.256	2.505	.690	.062	18.285	12586
310	.4570	757.17	33.07	6.40	3.227	2.475	.690	.062	18.240	12594
325	.4550	756.48	34.08	6.29	3.193	2.440	.691	.062	18.189	12603
340	.4530	756.09	34.65	6.11	3.173	2.420	.691	.062	18.159	12609
355	.4510	755.47	35.54	6.01	3.143	2.389	.692	.062	18.113	12617
370	.4480	755.18	35.96	5.83	3.129	2.375	.692	.062	18.092	12621
371	.4480	755.18	35.96	5.82	3.129	2.375	.692	.062	18.092	12621
385	.4420	752.26	38.39	6.06	3.045	2.289	.694	.062	17.966	12644
399	.4360	750.03	39.78	6.12	2.997	2.241	.694	.062	17.893	12658
413	.4310	748.87	41.00	6.07	2.955	2.196	.695	.062	17.830	12669
426	.4260	719.73	42.04	6.01	2.919	2.161	.696	.062	17.776	12679
435	.4270	715.79	42.73	5.89	2.895	2.137	.696	.062	17.740	12686
450	.4210	711.82	43.42	5.79	2.871	2.112	.697	.062	17.704	12692
465	.4240	707.97	43.94	5.67	2.854	2.094	.697	.062	17.676	12697
480	.4270	704.11	44.45	5.56	2.836	2.076	.697	.062	17.649	12702
495	.4300	700.26	44.97	5.45	2.818	2.058	.698	.062	17.622	12707
510	.4330	696.46	45.48	5.35	2.800	2.039	.698	.063	17.596	12712
525	.4360	692.63	45.99	5.26	2.782	2.021	.698	.063	17.569	12717

TABLE B-8. Continued

Exp.No.69 Continued

540	.5080	688.87	46.33	5.15	2.770	2.009	.699	.063	17.551	12720
555	.5100	685.14	46.67	5.05	2.758	1.997	.699	.063	17.533	12724
570	.5130	681.38	47.18	4.97	2.741	1.979	.699	.063	17.506	12728
585	.5150	677.86	47.51	4.87	2.729	1.967	.699	.063	17.488	12732
600	.5170	674.22	47.85	4.78	2.717	1.955	.700	.063	17.471	12735
615	.5190	670.57	48.18	4.70	2.706	1.943	.700	.063	17.453	12738
630	.5210	666.90	48.52	4.62	2.694	1.931	.700	.063	17.435	12741
645	.5230	663.22	48.85	4.54	2.682	1.919	.700	.063	17.418	12745
660	.5250	659.57	49.18	4.47	2.671	1.907	.700	.063	17.400	12748
675	.5260	655.97	49.35	4.39	2.665	1.901	.701	.063	17.392	12749
690	.5280	652.53	49.68	4.32	2.653	1.890	.701	.063	17.374	12753
705	.5300	648.89	50.00	4.26	2.642	1.878	.701	.063	17.357	12756
720	.5320	645.37	50.33	4.19	2.630	1.866	.701	.063	17.339	12759
735	.5340	641.84	50.66	4.14	2.619	1.855	.701	.063	17.322	12762
750	.5360	638.33	50.98	4.08	2.607	1.843	.702	.063	17.305	12765
FROM FINAL COAL ANALYSIS			70.49		2.240	1.130	.780	.330	16.250	12382

TABLE B-9. Continued

SUMMARY OF REACTION DATA FOR SO4/S= 1.500 LOWER KITTANNING, -100 MESH. EXP.NO.60 5.2% Fe, no Fe^{+2}

MIN FROM START	FE+2/FE WT. RATIO	COAL WT. FREE OF S(ELEM)	PYRITE REMOVED PCT OF INIT	CUMULATIVE RATE PCT/HR	CALCULATED COAL ANALYSES STEP-BY-STEP TOTAL S WT-PCT	PYR. S WT-PCT	ORG. S WT-PCT	SO4 S WT-PCT	ASH WT-PCT	HT CONTENT BTU/LB
15	.0731	923.39	30.61	122.45	3.292	2.546	.685	.061	18.831	12499
30	.0895	916.45	37.56	75.13	3.052	2.302	.688	.062	18.585	12548
45	.1039	910.08	43.69	58.26	2.839	2.085	.691	.062	18.365	12591
60	.1134	905.12	47.71	47.71	2.698	1.942	.693	.062	18.220	12619
75	.1222	900.35	51.45	41.16	2.566	1.808	.695	.062	18.084	12646
90	.1298	895.91	54.71	36.47	2.450	1.691	.697	.062	17.965	12669
105	.1353	892.06	57.07	32.61	2.366	1.606	.698	.063	17.879	12686
120	.1399	888.47	59.05	29.52	2.296	1.534	.699	.063	17.806	12700
150	.1512	883.04	63.86	25.54	2.123	1.358	.701	.063	17.628	12735
180	.1579	878.67	66.75	22.25	2.019	1.253	.703	.063	17.521	12756
210	.1649	874.52	69.75	19.93	1.909	1.142	.705	.063	17.408	12778
240	.1708	870.65	72.33	18.08	1.816	1.047	.706	.063	17.312	12797
270	.1756	867.02	74.38	16.53	1.741	.970	.707	.063	17.235	12812
300	.1793	863.65	75.98	15.20	1.682	.911	.708	.063	17.174	12824
330	.1828	860.36	77.51	14.09	1.626	.854	.709	.063	17.117	12835
360	.1891	856.30	80.25	13.38	1.525	.751	.710	.064	17.013	12856
FROM FINAL COAL ANALYSIS			82.68		1.680	.660	.770	.250	16.920	12895

TABLE B-10. EFFECT OF CONCURRENT REAGENT REGENERATION ON ABOVE AMBIENT PRESSURE PYRITIC SULFUR EXTRACTION FROM COAL

SUMMARY OF REACTION DATA FOR SO4/S= 1.500 LOWER KITTANNING, -1/4 X +10 MESH, N2, 120C. EXP.NO.61 5.1% Fe, no Fe^{+2}

MIN FROM START	FE+2/FE WT. RATIO	COAL WT. FREE OF S(ELEM)	PYRITE REMOVED PCT OF INIT	CUMULATIVE RATE PCT/HR	CALCULATED COAL ANALYSES STEP-BY-STEP TOTAL S WT-PCT	PYR. S WT-PCT	ORG. S WT-PCT	SO4 S WT-PCT	ASH WT-PCT	HT CONTENT BTU/LB
10	.0609	476.27	6.31	37.89	4.933	4.428	.364	.141	23.795	11334
20	.0711	475.48	7.37	22.12	4.891	4.385	.364	.142	23.700	11350
30	.0793	474.83	8.23	16.46	4.857	4.351	.365	.142	23.622	11363
40	.0875	474.21	9.07	13.60	4.824	4.317	.365	.142	23.546	11376
50	.0943	473.68	9.77	11.73	4.796	4.288	.366	.142	23.482	11387
60	.1009	473.17	10.45	10.45	4.769	4.260	.366	.142	23.420	11397
70	.1096	472.51	11.33	9.71	4.733	4.224	.366	.143	23.339	11411
80	.1154	472.07	11.92	8.94	4.709	4.200	.367	.143	23.285	11420
90	.1199	471.73	12.37	8.25	4.691	4.181	.367	.143	23.243	11427
100	.1254	471.33	13.05	7.83	4.664	4.154	.367	.143	23.181	11437
110	.1302	471.05	13.51	7.37	4.646	4.135	.368	.143	23.139	11444
120	.1362	470.61	14.00	7.00	4.626	4.115	.368	.143	23.093	11452
130	.1434	469.93	14.71	6.54	4.597	4.085	.368	.143	23.027	11463
140	.1502	469.28	15.35	6.15	4.570	4.057	.369	.143	22.965	11474
150	.1559	468.85	15.73	5.79	4.547	4.034	.369	.144	22.914	11482
165	.1630	468.49	16.70	5.57	4.516	4.002	.370	.144	22.842	11494
195	.1675	468.22	17.06	5.25	4.501	3.987	.370	.144	22.808	11500
210	.1733	467.80	17.62	5.04	4.478	3.964	.370	.144	22.756	11509
225	.1799	467.33	18.25	4.87	4.452	3.938	.371	.144	22.697	11519
240	.1827	467.12	18.52	4.63	4.441	3.926	.371	.144	22.672	11523
FROM FINAL COAL ANALYSIS			19.39		4.230	3.890	.220	.120	22.590	11446

TABLE [illegible]. Continued

SUMMARY OF REACTION DATA FOR SO4/S= 1.500 LOWER KITTANNING, -1/4 X +10 MESH, N2, 140C. EXP. NO.62 5.0% Fe, no Fe^{+2}

MIN FROM START	FE+2/FE WT. RATIO	COAL WT. FREE OF S(ELEM)	PYRITE REMOVED PCT OF INIT	CUMULATIVE RATE PCT/HR	CALCULATED COAL ANALYSES STEP-BY-STEP TOTAL S WT-PCT	PYR. S WT-PCT	ORG. S WT-PCT	SO4 S WT-PCT	ASH WT-PCT	HT CONTENT BTU/LB
10	.0613	500.88	5.90	35.39	4.934	4.431	.362	.141	24.063	11293
20	.0711	500.39	6.84	20.53	4.895	4.391	.363	.141	24.015	11302
30	.0797	499.95	7.67	15.33	4.860	4.356	.363	.141	23.974	11310
40	.0876	499.55	8.43	12.64	4.828	4.324	.363	.141	23.935	11317
50	.0959	499.13	9.22	11.07	4.795	4.290	.364	.141	23.895	11324
60	.1026	498.80	9.85	9.85	4.768	4.263	.364	.141	23.862	11330
70	.1098	498.43	10.54	9.03	4.739	4.234	.364	.142	23.827	11337
80	.1145	498.20	10.98	8.23	4.721	4.215	.364	.142	23.805	11341
90	.1215	497.86	11.63	7.75	4.693	4.187	.364	.142	23.771	11347
100	.1281	497.53	12.25	7.35	4.667	4.160	.365	.142	23.740	11353
110	.1294	497.47	12.37	6.75	4.662	4.155	.365	.142	23.734	11354
120	.1378	497.06	13.14	6.57	4.629	4.122	.365	.142	23.694	11361
135	.1456	496.68	13.85	6.16	4.598	4.091	.365	.142	23.657	11368
150	.1548	496.24	14.70	5.88	4.563	4.055	.366	.142	23.614	11376
165	.1614	495.92	15.29	5.56	4.537	4.029	.366	.142	23.583	11381
180	.1679	495.61	15.88	5.29	4.512	4.003	.366	.142	23.553	11387
195	.1724	495.40	16.29	5.01	4.494	3.986	.366	.142	23.532	11391
210	.1806	495.01	17.02	4.86	4.463	3.954	.367	.143	23.494	11398
225	.1866	494.73	17.55	4.68	4.440	3.931	.367	.143	23.466	11403
240	.1906	494.54	17.90	4.48	4.425	3.916	.367	.143	23.448	11406
FROM FINAL COAL ANALYSIS			20.55		5.070	3.800	.460	.810	23.310	11390

TABLE B-10. Continued.

SUMMARY OF REACTION DATA FOR SO4/S= 1.500 LOWER KITTANNING, -100 MESH, N2, 130C. EXP.NO.63 4.9% Fe, no Fe^{+2}

MIN FROM START	FE+2/FE WT. RATIO	COAL WT. FREE OF S(ELEM)	PYRITE REMOVED PCT OF INIT	CUMULATIVE RATE PCT/HR	CALCULATED COAL ANALYSES STEP-BY-STEP TOTAL S WT-PCT	PYR. S WT-PCT	ORG. S WT-PCT	SO4 S WT-PCT	ASH WT-PCT	HT CONTENT BTU/LB
30	.1671	504.12	20.04	40.07	3.664	2.921	.682	.061	18.937	12467
40	.1796	500.00	21.56	32.35	3.613	2.869	.683	.061	18.863	12481
50	.1859	495.73	22.34	26.80	3.587	2.843	.683	.061	18.826	12488
60	.1950	491.33	23.44	23.44	3.550	2.805	.684	.061	18.772	12498
70	.1998	487.75	24.04	20.60	3.530	2.785	.684	.061	18.743	12503
80	.2051	484.05	24.68	18.51	3.509	2.763	.685	.061	18.712	12509
90	.2214	480.07	26.69	17.79	3.441	2.694	.686	.061	18.614	12527
100	.2359	475.35	28.48	17.09	3.381	2.632	.687	.062	18.526	12543
110	.2469	470.93	29.84	16.27	3.335	2.585	.688	.062	18.459	12556
120	.2574	466.54	31.13	15.56	3.291	2.541	.689	.062	18.396	12567
135	.2649	463.07	32.06	14.25	3.259	2.508	.689	.062	18.349	12576
150	.2710	459.34	32.82	13.13	3.233	2.482	.690	.062	18.312	12583
165	.2803	455.54	33.98	12.36	3.194	2.442	.690	.062	18.255	12593
180	.2875	451.05	34.87	11.62	3.163	2.411	.691	.062	18.210	12601
195	.2818	447.23	34.16	10.51	3.188	2.436	.690	.062	18.246	12595
210	.2757	443.46	33.41	9.55	3.213	2.462	.690	.062	18.283	12588
225	.2768	439.30	33.54	8.94	3.209	2.457	.690	.062	18.276	12589
240	.2800	435.07	33.93	8.48	3.195	2.443	.690	.062	18.257	12593
FROM FINAL COAL ANALYSIS			81.00		2.85	0.68	.690	1.480	18.280	9589*

*Possible analysis error. Additional sample for recheck analysis was not available.

TABLE B-10. Continued

SUMMARY OF REACTION DATA FOR SO4/S= 1.500 LOWER KITTANNING, -100 MESH, 02, 130C. EXP.NO.64 5.1% Fe, no Fe^{+2}

MIN FROM START	FE+2/FE WT. RATIO	COAL WT. FREE OF S(ELEM)	PYRITE REMOVED PCT OF INIT	CUMULATIVE RATE PCT/HR	CALCULATED COAL ANALYSES STEP-BY-STEP TOTAL S WT-PCT	PYR. S WT-PCT	ORG. S WT-PCT	SO4 S WT-PCT	ASH WT-PCT	HT CONTENT BTU/LB
10	.0928	530.82	11.17	67.03	3.953	3.217	.676	.061	19.437	12378
20	.0754	528.05	9.00	27.19	4.023	3.288	.675	.060	19.523	12361
30	.0630	524.61	7.56	15.13	4.073	3.338	.674	.060	19.584	12350
40	.0563	520.91	6.75	10.12	4.099	3.365	.674	.060	19.617	12344
50	.0506	517.33	6.07	7.28	4.122	3.388	.673	.060	19.645	12338
60	.0481	513.69	5.77	5.77	4.132	3.398	.673	.060	19.657	12336
70	.0461	509.52	5.53	4.74	4.139	3.406	.673	.060	19.667	12334
80	.0664	504.47	7.96	5.97	4.059	3.325	.674	.060	19.568	12353
90	.0581	500.78	6.97	4.65	4.092	3.358	.674	.060	19.608	12345
100	.0674	496.15	8.09	4.85	4.055	3.321	.674	.060	19.563	12354
110	.0665	492.05	7.98	4.35	4.059	3.324	.674	.060	19.567	12353
120	.0670	487.89	8.04	4.02	4.057	3.322	.674	.060	19.565	12353
FROM FINAL COAL ANALYSIS			84.00		2.36	0.56	.830	.97	17.480	11810

TABLE B-11. Sulfate to Sulfur Ratio Computations

The "sulfate to sulfur" ratio

$$R_s = \frac{SO_4}{S^0} = \frac{\text{Sulfate sulfur from removed pyrite}}{\text{Elemental sulfur from removed pyrite}} \qquad (1)$$

was computed directly from the recovered sulfate (spent ferric chloride solutions and wash water) and elemental sulfur (spent toluene residue upon distillation) in the ferric chloride system (ferric chloride extractions of coal). In the ferric sulfate system, the produced sulfate from coal pyrite oxidation was overwhelmed by the sulfate of the reagent and its accurate determination proved impossible. Thus, R_s was indirectly determined from iron forms data (ferric ion consumed or ferrous ion produced) and the elemental sulfur recovered from toluene. The expression used (quantities in moles) was

$$R_s = \frac{(Fe^{+3} - S^0)/7}{S^0} = \frac{(Fe^{+2} - 1.5S^0)/7.5}{S^0} \qquad (2)$$

and it was derived from the chemistry of the process

$$Fe^{+3} + 0.5\ FeS_2 = 1.5\ Fe^{+2} + S^0$$

$$7Fe^{+3} + 0.5\ FeS_2 + 4H_2O = 7.5\ Fe^{+2} + SO_4^{=} + 8H^+$$

which shows that each mole of formed elemental sulfur requires one mole of Fe^{+3} to be consumed and produces 1.5 moles of Fe^{+2}; the corresponding quantities for the formation of one mole sulfate are 7 moles Fe^{+3} (consumed) and 7.5 moles Fe^{+2} (produced). Thus, the quantities

$$(Fe^{+3} - S^0)/7 \quad \text{and} \quad (Fe^{+2} - 1.5S^0)/7.5 \qquad (3)$$

represent the sulfate formed from the oxidation of pyrite by ferric ion. The assumption is made that side reactions consuming ferric ion or producing ferrous ion or sulfate do not take place. For example, Expression (2) can not be applied to Illinois No.5 coal which exhibits some reaction of ferric ion with species other than pyrite (probably with the coal matrix). It was found valid for Lower Kittanning coal.

TABLE B-11. Continued

The R_s values derived from Expression (2) were checked against

$$R_s = \frac{\Delta Sp - S^0}{S^0} \quad \text{or} \quad R_s = \frac{\Delta S_t - (\Delta S_0 + \Delta SO_4 + S^0)}{S^0} \qquad (4)$$

where

Δ = change in indicated quantity, before-after coal processing

S_p = pyritic sulfur in coal

S_t = total sulfur in coal

S_0 = organic sulfur in coal

$SO_4^=$ = sulfate sulfur in coal

S^0 = elemental sulfur produced from pyrite

Expression (4) utilizes total sulfur and sulfur forms analyses of starting and processed coal as well as the recovered elemental sulfur, S^0.